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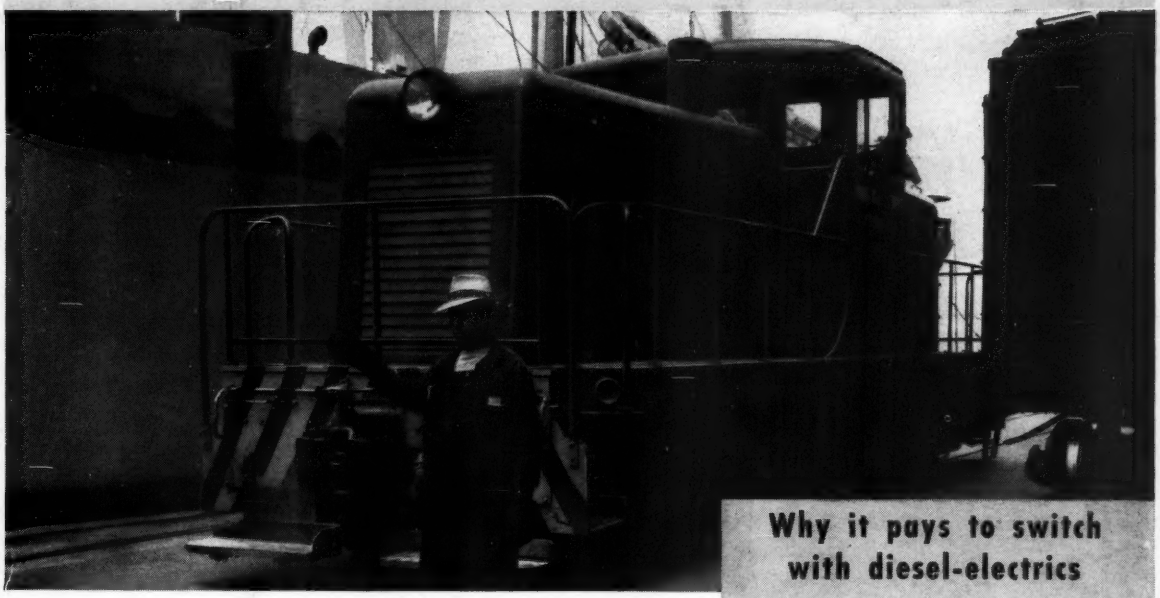

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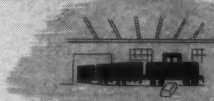

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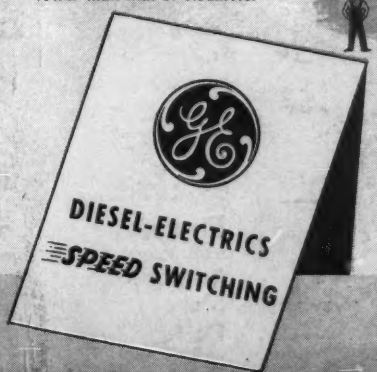


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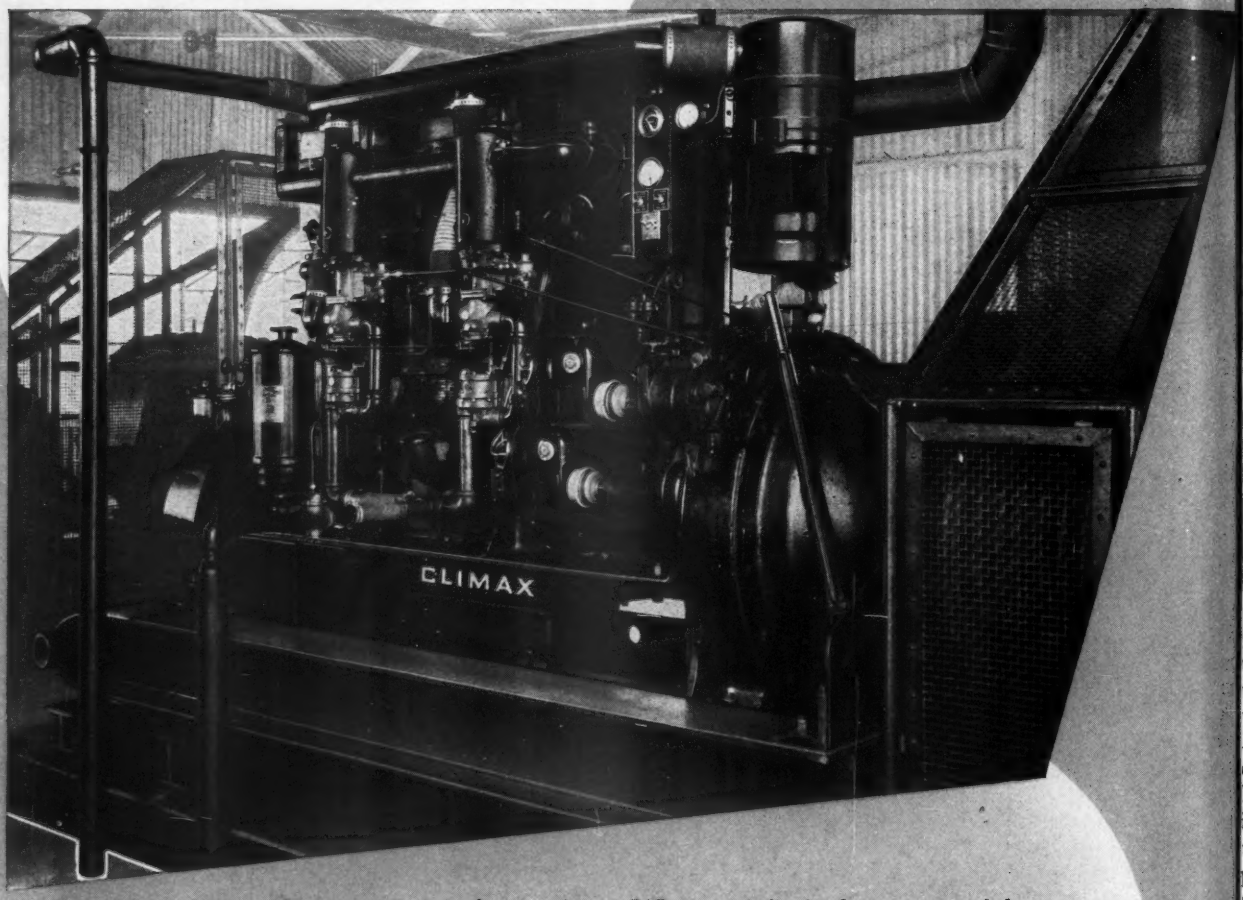


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CALIFORNIA
# OIL WORLD

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FOR TIMELY, COMPLETE
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December 15th, 1944
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Carrington Kung

Two first-class rows involving the oil industry broke in Washington at the month's end, with the controversial Anglo-American petroleum treaty unceremoniously booted out of the Senate Foreign Relations Committee by Chairman Tom Connally of Texas, and Assistant Attorney General Norman M. Littell being fired from his Justice Department job by President Roosevelt.

Connally's action in making a prediction the treaty would not be ratified by his committee came on the very day the National Oil Policy Committee of the Petroleum Industry War Council met in Washington to ponder a set of revisions to the treaty requested by Petroleum Administrator Ickes. It was received in stunned silence by State Department and Petroleum Administration officials who worked through the summer with a hand-picked delegation of oil experts from Great Britain to resolve difficulties between this government and our British allies over American and British oil holdings abroad.

The Littell dismissal is indirectly pleasing to many oil men because of the long feud between the New Dealer and the industry which has flared each time a petroleum matter came within the reach of Littell and his Lands Division. While the lurid battle between Littell and his superior, Attorney General Francis Biddle, appears to most observers an instance of the "pot calling the kettle black" and while most oil men are hoping Biddle will quickly follow Littell in receiving the Presidential heave-ho, Littell's removal alleviates some of the industry's nervousness over an early revival of the dispute concerning ownership of the tidelands.

**Serious split between the industry and PAW was avoided when the National Oil Policy Committee not only submitted specific revisions to the existing Anglo-American oil pact but succeeded in gaining PIWC's endorsement of the revisions and of an accompanying report.**

**Revolt supported by certain council members who urged a six week's delay in action on the committee's recommendations was put down when Secretary Ickes made "very forceful statement" calling for endorsement before adjournment. Ickes told assembled oil men in effect there was going to be international collaboration after the war whether the oil industry wanted it or not and appealed for their support.**

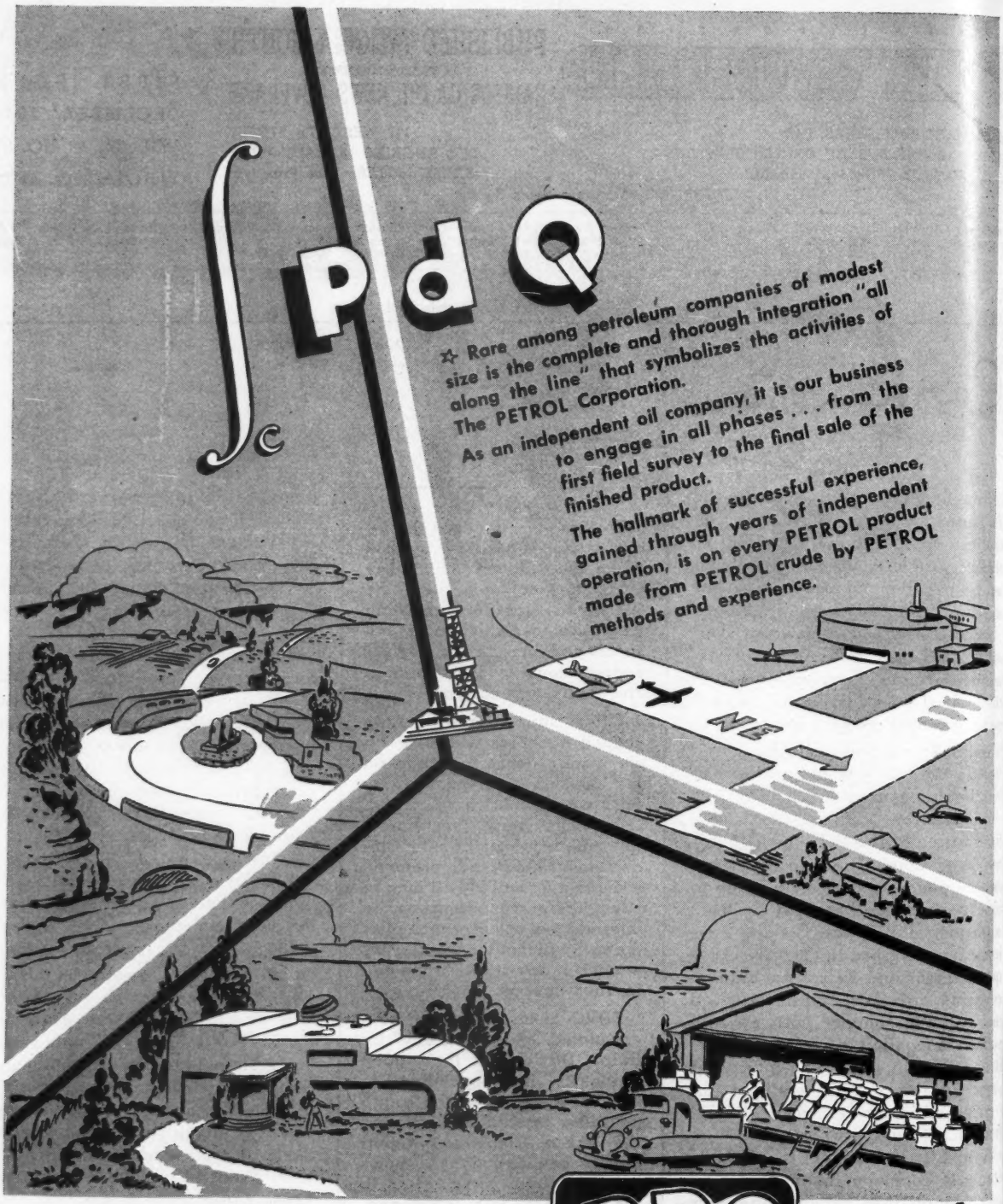
**PIWC members were congratulated "most earnestly" by Ralph Davies, on their good judgment in responding to Ickes request, when the group passed a resolution supporting the Policy Committe's report and recommendations. Davies refrained from comment as to the merits of the recommendations until he could study them but feeling here is that today's action comes closer to reestablishing industry-government relations than anything that has occurred in recent months. Council passed resolution unanimously except for "four or five" members not voting.**

---

The Anglo-American treaty matter is approaching its real climax as this is being written. Although the Oil Policy Committee still is meeting behind closed doors, its report will be the first order of business (and probably the only order of business) when PIWC launches its December clambake. . . . This will be just as CALIFORNIA OIL WORLD goes to press, but we'll hope for time to wire any important last-minute details.

Meanwhile, the bolt from the blue which Senator Connally let go on Dec. 2 appears to be back-firing. The violent partisanship displayed by the Texas Railroad Commission, and certain Texas independents and companies which have been screaming bloody murder whenever the treaty is mentioned, is said to have made its impression on the Senator from Texas. Even the conservative Washington Post found "ominous implications" in the effort made by the chairman of the powerful Foreign Relations Committee to "smother the Anglo-American oil pact".

"This is outrageous conduct," the Post said, sternly. "It is just such shortsighted and undemocratic tactics that have undermined the confidence of other nations in the U. S.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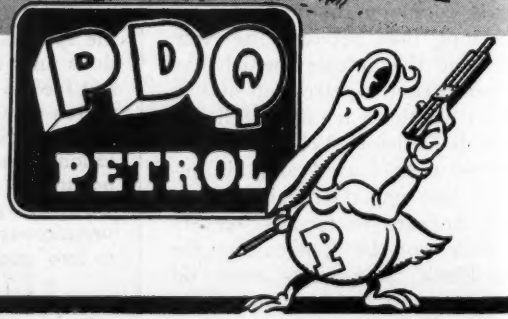

as a major factor in promoting world stabilization. The least the committee could do would be to hold hearings on the pact, to propose amendments, if it must, and then to send the treaty back to the Senate. Any less responsible action, or inaction, on its part will come like a wave of cold water over the United Nations peace conference."

The State Department and the Petroleum Administration for War were equally concerned over Connally's impulsive announcement. Particularly as the oil treaty was destined to blaze the trail for other international agreements on the control and distribution of other world commodities.

The principal concern of Deputy Petroleum Administrator Ralph K. Davies was that the industry will lay itself open to charges of isolationism by actively fighting what amounts to the first real effort toward international cooperation.

"Oil will be one of the chief commodities to be dealt with in the winning of the peace," Davies told this writer. "It would make for a very poor beginning if this collaboration should be destroyed by the oil industry as it is a national issue of greatest significance."

The Standard Oil Co. of California vice-president indicated, however, that he had every confidence in the industry when it came to a show-down on the treaty. He was sure, he said, that the Oil Policy Committee would offer the requested recommendations, and equally sure the industry "will not make the mistake" of repudiating all portions of the agreement that originally was proposed by industry members.

Connally's renunciation of the treaty was tantamount to killing off the agreement and its chances for a review by the Senate. It is expected that the White House or the State Department will withdraw the document; that any industry suggestions for changes in the language that may come out of the turbulent PIWC meeting will be considered and that the treaty may be redrafted and submitted as an executive agreement,—thus neatly by-passing Connally and his committee.

While proponents of the treaty mark time for a bulletin from PIWC, rumors already suggest that some Council members are becoming jittery. Public reaction to the Connally statement so far has resulted in turning the eyes of Congress upon Texas.

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The spirited exchange of insults between Norman Littell and his erstwhile boss, Attorney General Biddle, has become a familiar page-one feature in newspapers throughout the country. Both before and after Littell was removed from office by President Roosevelt for "insubordination", the head of the Justice Department's Lands Division was furnishing Congressional investigation committees with tasty details on the asserted friendship between Biddle and Thomas G. ("Tommy the Cork") Corcoran,—legendary New Deal lobbyist and former White House confidant.

For some time it has been reported Littell was in possession of much confidential information—inter-office memoranda, transcripts of conversations, etc.—of a nature embarrassing to Biddle. His charges against his superior have so far distracted attention from Littell's own record,—a record that California oil men have followed with interest.

Littell, it will be recalled, once held that Congress had "no right" to legislate on the matter of tideland oil deposits and told a California member of Congress that the tidelands "belong to us (the Government)" and not to the States involved. In addition to his interest in seeing title to the offshore oil deposits established in the Federal Government, Littell made a vigorous drive to have the Elk Hills oil properties of Standard Oil Co. of California condemned by the Government. It was he who publicly charged the California oil company and the Navy Department with conniving for a "second Teapot Dome" and the lengthy battle he fought before the House Public Lands Committee, in the summer of 1943, was responsible for the delay in clearing the joint agreement under which Standard of California and the Navy now are operating the Elk Hills reserve,—a delay quite costly to the war effort.

Most of Littell's witch-hunting has been directed at Standard. The New Dealer took time-out before the recent elections to give a helping hand to Representative Jerry Voorhis, in California's 12th District, appearing on a radio broadcast over KPAS where he was introduced by Frank Burke. In introducing Littell, the Pasadena radio man announced the Justice Department official also had addressed "a great meeting under the auspices of informed democracy", interpreted by Californians to mean J. A. Smith's Independent Petroleum Consumers' Association.

Littell, Burke said, "in unbounded measure had the same spirit as Voorhis in his desire to keep public interest in mind, and with determination to carry on public work".

In the Oct. 27 radio speech, Littell said it was "utterly untrue" that the new contract between the Navy and Standard was little changed from the earlier agreement cancelled through Justice Department pressure. He confined himself, however, to the fact that any revision of percentages will be retroactive to the original date of contract and summed up by stating there was a great net gain in the repudiation of the old contract, even though the new contract has some similar features.

For this and other kindly gestures in his direction, Voorhis—now safely back in Congress—showed his gratitude by jumping into the current Biddle-Littell hair-pulling contest on the side of Littell. The California Congressman now is leading the campaign to have Biddle's charges against Littell investigated by Congress, and has introduced a resolution for this purpose.

---

Despite industry opposition to the movement of West Texas crude into California, under the new agreement of the Reconstruction Finance Corp. to absorb most of the additional freight costs, PAW is determined to see the program through. Officials in Washington point out that, even if Pacific Coast refiners have a justifiable complaint against the quality of the crude, it is important to the war effort to see that stocks are built up before

*(Continued on Page 19)*

# Vibration in Compressor Plant Piping

**M. L. Arnold**
**Richfield Oil Corporation**

December, 1944
Meeting

The use of compression equipment at high rotative speeds and high operating pressures has made many of us uncomfortably aware of a phenomenon called vibration, which arises specter-like and imparts the shakes to piping, designers, and operators. After once having been responsible for a condition of this kind, engineers dream of designing a plant which is entirely free of vibration.

The purpose of this paper is to describe the avenues by which the engineer may be able to approach this Utopia. But first, we will briefly discuss the mechanical effect of vibration on piping, the mechanics of vibration, and the origin of the forces causing vibration in compressor plant piping.

If piping is subjected to a stress statically applied, it will rupture only if the stress exceeds the ultimate tensile stress of the metal composing the pipe wall. However, if the pipe is subjected to repeated bending, such as occurs during vibration, rupture may occur even though the maximum stress in the metal has been far less than the ultimate tensile stress. Rupture of this type is referred to as fatigue failure.[1]

In general, fatigue failure due to vibration is most likely to occur in highly stressed portions of the piping system, such as expansion bends, than in less stressed portions such as straight runs. Failure will occur earlier if the magnitude, or amplitude, of the vibration is large than if the amplitude is small. It will occur at points where non-uniformities such as notches or changes in cross section occur, rather than in uniform sections of piping.

Some of these points are illustrated in Figures 1, 2, and 3. Figure 1 shows that the number of times a piece of steel can be bent before rupture occurs increases as the maximum bending stress decreases. The stress was varied from that shown on the figure to zero and back during each cycle. Such a curve is called an S-N curve. If a complete reversal of stresses had been effected during each cycle, that is, if the stresses had been varied from a tensile stress to a compressive stress of the same magnitude and back, the S-N curve would be parallel to the one shown, but at each point failure would have occurred at a lesser value of maximum stress. The value of the stress over the horizontal portion of the curve is referred to as the endurance limit of the material.

Figure 2 shows the effect of various types of irregularities in cross sections upon fatigue strength. Irregularities of form such as holes, threads, notches, sharp shoulders, etc., when present in a pipe or other member may produce localized stresses. These stresses may be much greater than the stress calculated by the ordinary formulas of mechanics. For this reason irregularities in section must be considered in estimating the fatigue strength of piping.[2]

Figure 3 illustrates the effect of maximum stress and stress range upon endurance strength. The ordinate is in percent of the ultimate tensile strength of ferrous metal and the abscissa is arbitrary. It is apparent that if the maximum stress is high, only a small range of stresses can be tolerated during each cycle. If a complete reversal of stresses occurs, the maximum permissible stress is 33 percent of the ultimate tensile stress.[3] If the maximum stress is greater than that shown in the diagram, then the range between the maximum and minimum stress must be reduced by reducing the amplitude of the vibratory motion.

The simplest type of vibratory motion is known as free harmonic vibration.[4] It is the type of motion which would be described if a system composed of a weight suspended on a frictionless spring were set in motion in a frictionless medium and no external force acted upon it. If friction is present, either in the spring or in the medium, the resulting motion is called free damped vibration.

The maximum displacement of a vibrating member, such as the

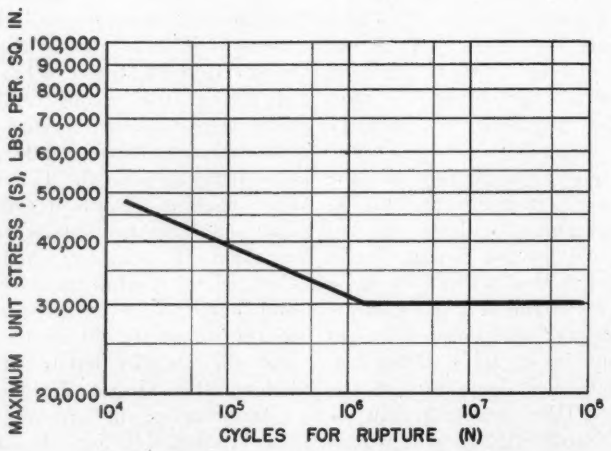


FIGURE. I - TYPICAL S-N DIAGRAM FOR A FERROUS METAL

REFERENCE - JOHNSON: MATERIALS OF CONSTRUCTION

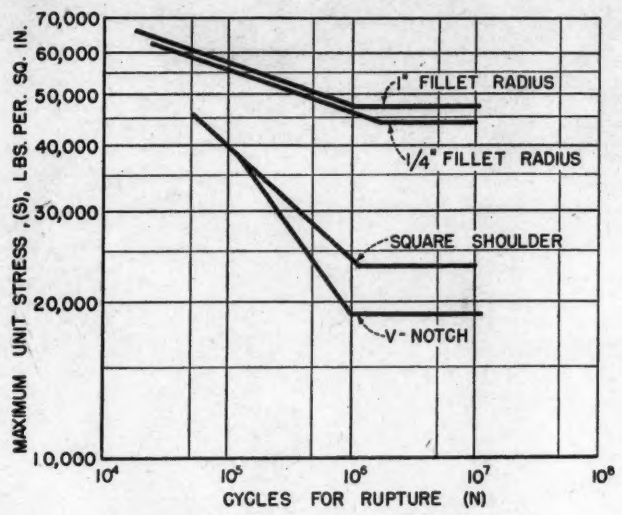


FIGURE. 2 - S-N DIAGRAM FOR SPECIMENS OF IRREGULAR CROSS SECTION

REFERENCE - JOHNSON: MATERIALS OF CONSTRUCTION

weight referred to, is called the amplitude of the vibration. The movement from one position of maximum displacement, through the mean position to the opposite position of maximum displacement and return to the orgiinal position is known as a cycle, the time required to complete one cycle as the period, and the number of cycles described per unit of time as the frequency.

If a system capable of vibrating is set in motion, and no retarding forces act upon it, the frequency at which it oscillates is known as its natural frequency of vibration. If the motion is retarded (damped), both the amplitude and the frequency of the motion is diminished.

If the retarding force is increased gradually, a value will be found for which the system will not vibrate, but when displaced from its position of rest, will slowly return to this position. The amount of damping just sufficient to effect this is called "critical damping."

The effect of damping on the natural frequency of vibration is given in Figure 4. The ratio of the damped to the undamped natural frequency is shown as a function of the coefficient of damping. This coefficient is defined as the ratio of actual damping to critical damping. For the degree of damping ordinarily experienced, it can be assumed that the natural frequency is not affected.

In compressor plants we are interested, not in free damped vibration, but in forced damped vibrations. Forced damped vibrations result from the action of periodic forces upon a system susceptible to vibration. Examples of such disturbing forces are those resulting from the periodic explosions of the charge in power cylinders and from the periodic discharge of gas from a compressor cylinder. If the frequency of the periodic force is the same as the natural frequency of vibration of the system to which it is applied, the periodic force is said to be in resonance with the system.

In general, the preceding remarks, and those which follow, apply to any system in which the static deflection of a member is a linear function of the force applied. A piece of pipe with the ends supported is such a system. Figure 5 shows the natural

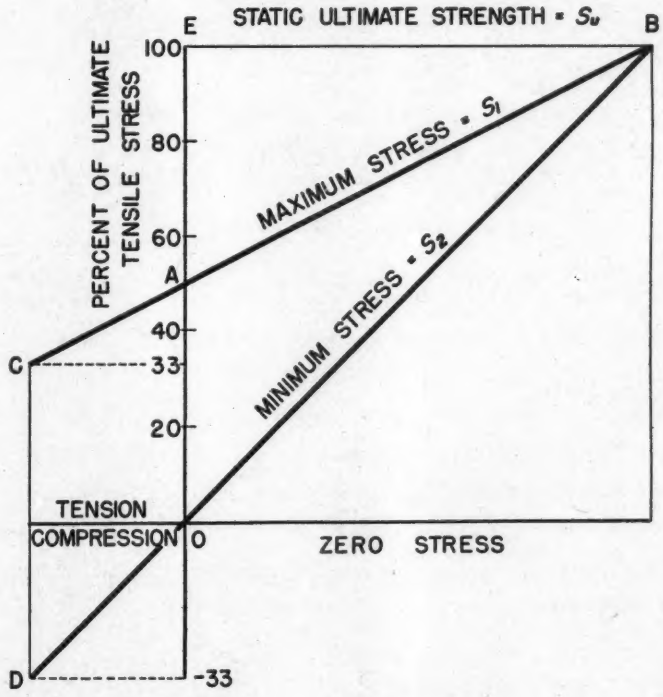


FIGURE. 3 - GOODMAN'S DIAGRAM - EFFECT OF STRESS AND STRESS RANGE ON ENDURANCE STRENGTH

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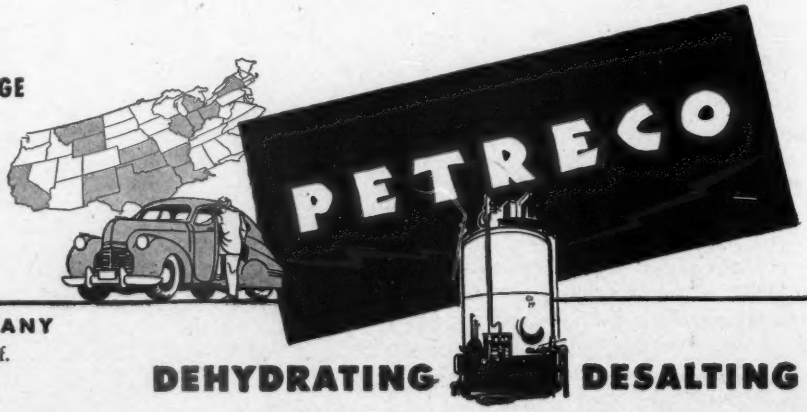


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frequency of vibration of various sizes of pipe supported in this manner, for various distances between supports.

If a force is statically applied to a section of piping supported as described, the deflection can be computed from the usual formulas for deflection of beams. However, when the force is applied periodically, the resulting deflection, or amplitude, may equal, exceed, or be less than the computed static deflection.

The ratio between the deflection obtained when the force is applied periodically and the deflection caused by the same force statically applied, is called the magnification factor.

This factor is variable with the ratio of the frequency of the applied force to the natural frequency of vibration of the system and with the coefficient of damping of the system. The relationship is shown in Figure 6. As shown by the figure, at resonance, a small disturbing force can cause a forced vibration of large amplitude.

If several disturbing periodic forces act simultaneously on a system, the amplitudes of the forces add algebraically. If the forces are of different frequency, beat frequencies result. For example, if the two periodic forces shown in Figure 7 act simultaneously on a system, the beat frequencies shown in Figure 8 result.

The disturbing periodic forces with which we are concerned in compressor plants originate from two sources. These are the rotating and reciprocating parts of the engine and compressor, and the discharge of gas from the compressor cylinders.

The magnitude of the forces created by the moving parts depends largely upon the degree to which these parts have been counterbalanced. The frequency of the force is a function of engine speed and the number of cylinders.

These forces are transmitted as pressure waves through the frame of the engine to the foundation and thence to the surroundings and piping. The pressure waves travel at a speed approximately equal to the velocity of sound in the material through which the wave is being transmitted.[6]

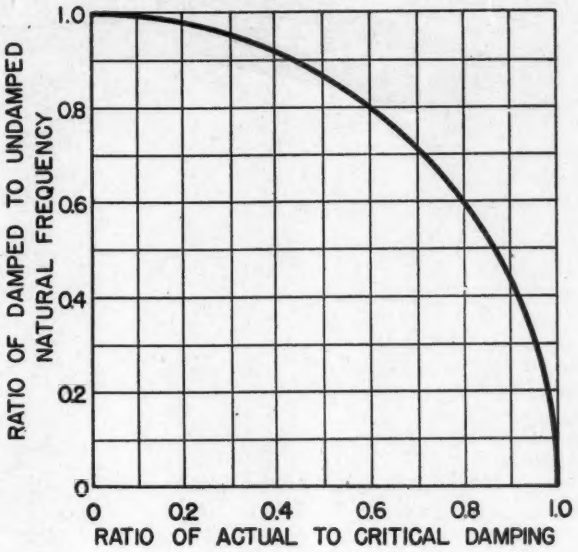


FIGURE. 4 - EFFECT OF DAMPING ON NATURAL FREQUENCY OF VIBRATION

REFERENCE - DEN HARTOG: MECHANICAL VIBRATIONS

The amplitude of the pressure waves is considerably reduced by damping during transmission. A further reduction in force occurs by reflection when the wave is transmitted from a material in which the velocity of propagation is high to one in which the velocity is lower. For example, at the interface between the cast iron bed plate and the concrete foundation, approximately 7 percent of the force of the wave is reflected back into the engine frame. The force is further reduced as the wave passes from concrete to dry earth. Even though these forces are greatly diminished before reaching the piping, they cannot be dismissed as possible causes of vibration. For it has been shown in Figure 5 that at resonance, the magnification factor may approach infinity, and very small forces cause vibrations of large amplitude.

The disturbance due to the periodic discharge of gas from the compressor cylinder is evidenced principally at points of change in direction of the piping. For when a fluid flowing through a pipe is made to change direction, as at a tee, elbow, or pipe bend, a reactive force is created. The magnitude of this force is proportional to the mass velocity of the flowing fluid and to the change in direction.[8] Since the velocity of flow from a compressor cylinder varies periodically, a periodic reactive force is created when the gas is caused to change direction. The frequency of the force is a function of the speed of the compressor, the number of cylinders connected to the line, the crank angle between the

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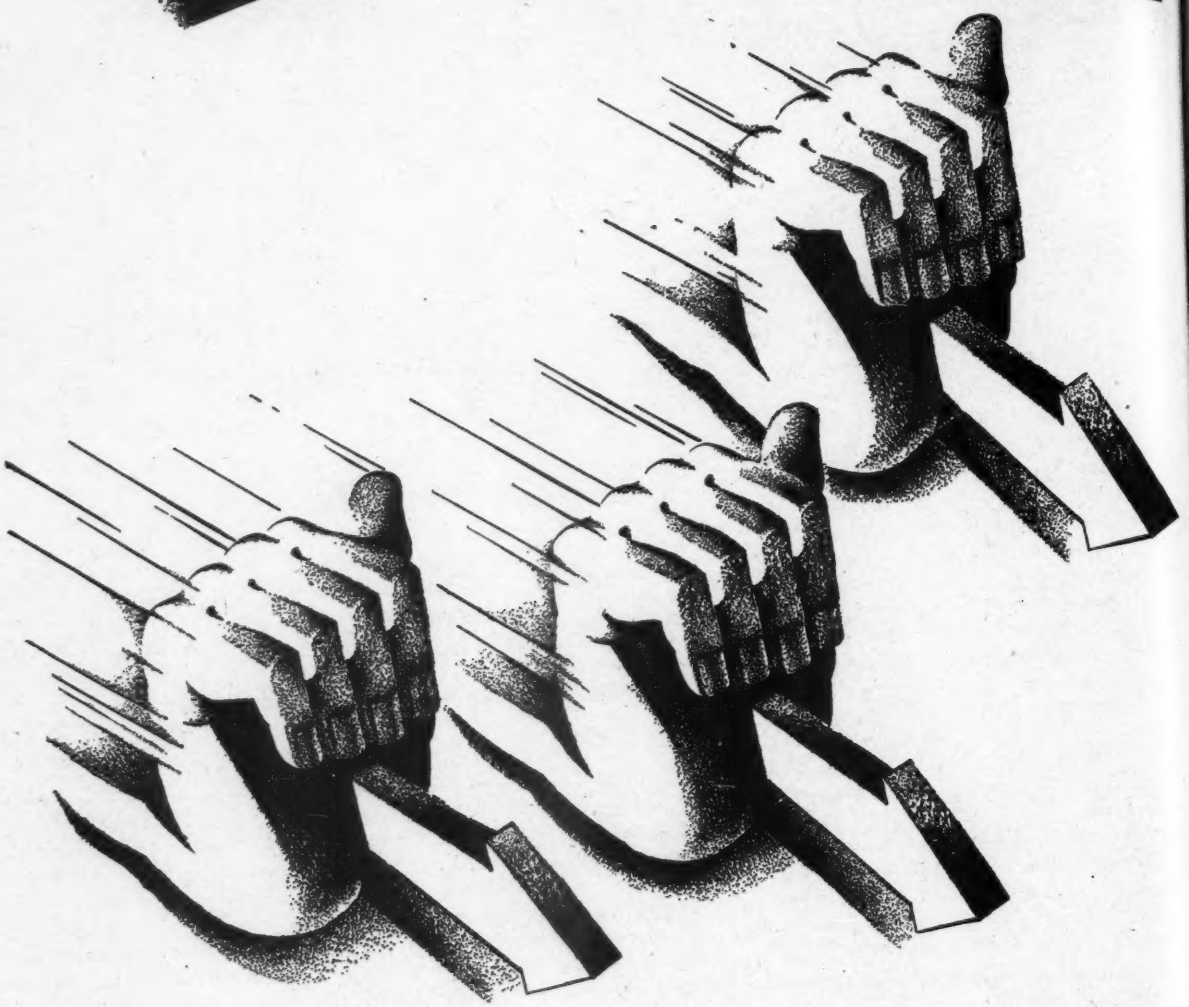

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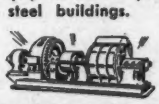

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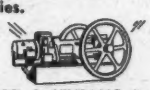

**BOVAIRD & SEYFANG** Pumping engines, jacks, "powers", storage tanks and allied supplies and equipment for oilfields.

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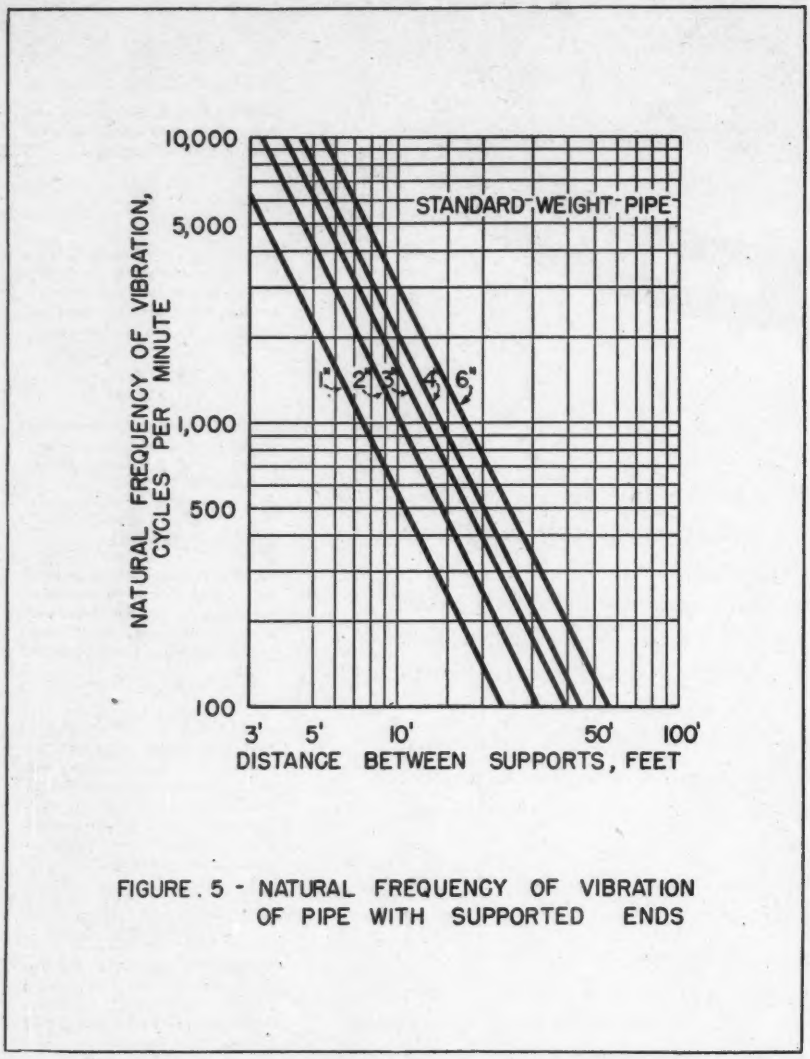



FIGURE. 5 - NATURAL FREQUENCY OF VIBRATION OF PIPE WITH SUPPORTED ENDS

cylinders, and whether the cylinders are single or double acting.[9]

This periodic discharge of gas is also sometimes responsible for the existence of abnormal pressures in compressor piping. This results from the formation of standing pressure waves in the piping. These are created by reflection when the length of a discharge pipe is such that its resonant frequency is equal to the frequency of the discharge of gas from the compressor cylinder. The resonant frequency of a pipe is a function of its length and the velocity of sound in the gas flowing through it.[10]

At this point we are in a position somewhat similar to that of a young man who has been sitting on a pier listening to a lecture on the theoretical aspects of swimming, such as the laws of gravity and buoyancy, but who has never been in the water. So suppose we all take a deep breath and prepare to try out some of the theory we have been listening to. But before actually taking the plunge, it might be well to briefly summarize the discussion so far. It can be done as follows:

1. Vibration in compressor plant piping is caused by periodic forces originating in the compression equipment.
2. These periodic forces are transmitted from the equipment to the piping either through the foundations and surroundings or by means of the flowing gas.
3. The vibration resulting from the application of these periodic forces to the piping is most likely to be destructive if the frequency of the forces is approximately equal to the natural frequency of vibration of the piping.

This summary indicates that there are three avenues of approach to the solution of the problem of designing a compressor plant which will be free of troublesome piping vibration. These avenues are as follows:

1. Design the compression equipment in such a way that all disturbing forces are eliminated.
2. Isolate the sources of disturbing forces from the piping system.
3. Design the piping system in such a way that it will not be affected by any of the periodic forces likely to occur.

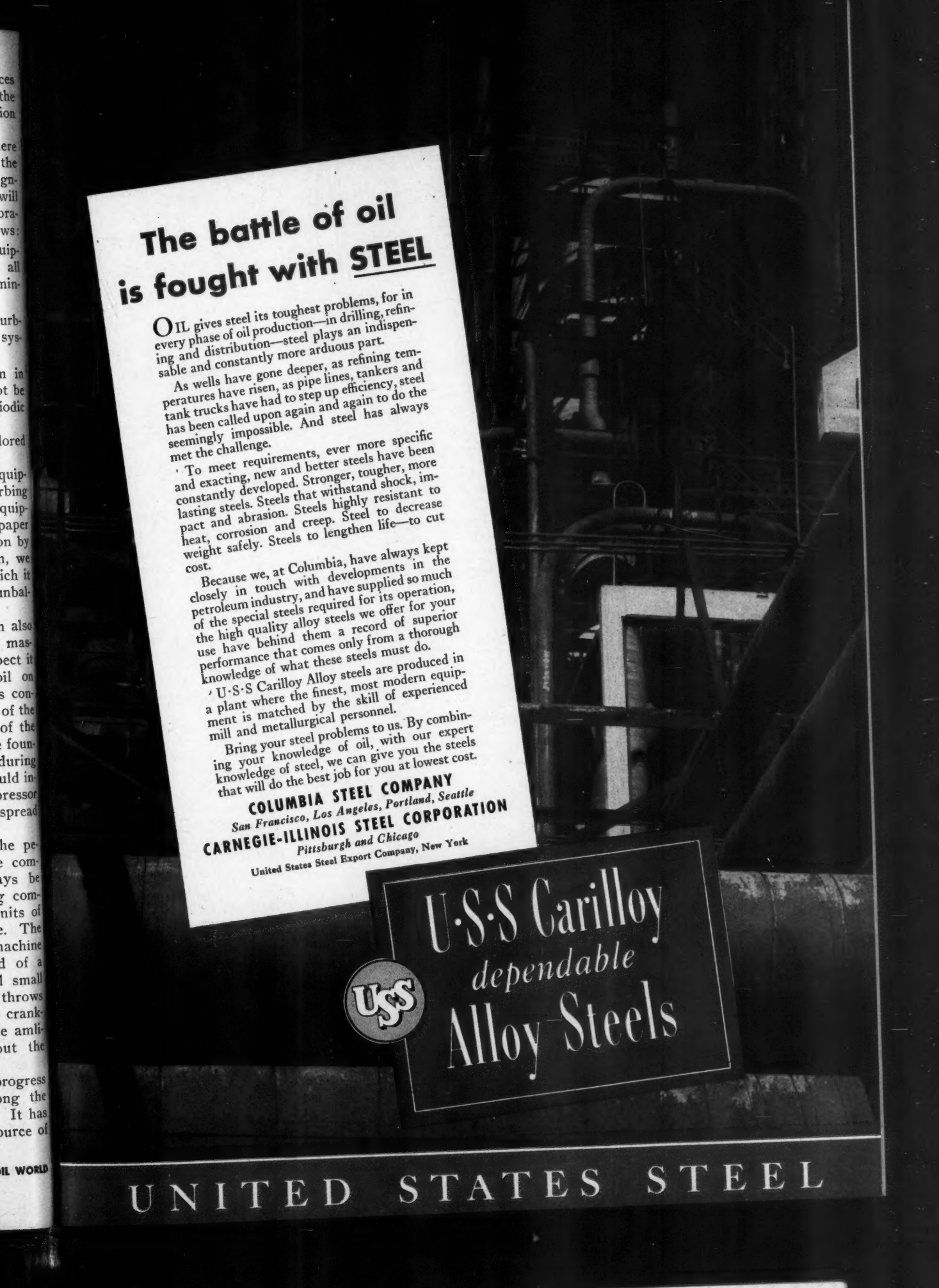
These avenues will be explored one by one.

The problem of designing equipment which is free of disturbing forces we will leave to the equipment manufacturers. In a paper presented before the Association by Messrs. Engleman and Chrzan, we were told of the extent to which it is possible to reduce engine unbalance.[8]

Forces due to unbalance can also be minimized by resorting to massive foundations. In this respect it has been stated that the soil on which a foundation rests adds considerably to the effective mass of the foundation because the mass of the soil, as well as the mass of the foundation must be accelerated during lateral vibration. [11] This would indicate the desirability of compressor foundations having large spread footings.

The forces arising from the periodic flow of gas from the compressors will probably always be with us, unless reciprocating compressors are replaced with units of the centrifugal or rotary type. The flow from a reciprocating machine can be improved, if instead of a single large cylinder several small cylinders are used, driven by throws uniformly spaced around the crankshaft. This will decrease the amplitude of the disturbance, but the frequency will be increased.

In other industries much progress has already been made along the second avenue of approach. It has been demonstrated that a source of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disturbing periodic forces, such as a gas engine, can be isolated from its surroundings with almost any desired degree of completeness by mounting the machine on elastic supports. For small masses, springs, rubber, corkboard and felt supports are available. For large masses springs, or springs in combination with one of the other materials, are generally used. It is stated that machines weighing up to 450 tons have been satisfactorily isolated in this way. [12]

Buildings have been isolated from vibrations transmitted to foundations by erecting the columns on pads made of alternate layers of lead and asbestos. [13]

Great care must be used in designing elastic supports. If improperly designed, the forces transmitted to the surroundings may be magnified rather than reduced.

The ratio of the force transmitted through an elastic support to the disturbing force is called the transmissibility of the support. The transmissibility is a function of the ratio of the frequency of the force being isolated to the natural frequency of vibration of the elastic support. Figure 9 shows, for various damping cofficients, how this ratio affects the transmissibility. It is apparent that unless the ratio is greater than 1.414, no reduction is accomplished, and that if the ratio is in the vicinity of one, the force transmitted to the surroundings is increased.

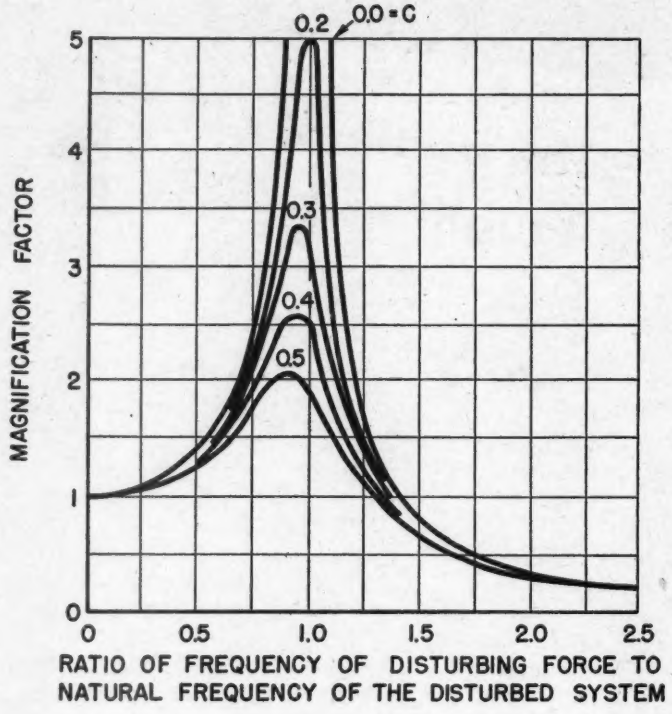


FIGURE. 6 - MAGNIFICATION FACTOR

REFERENCE - MARKS: MECHANICAL ENGINEERS HANDBOOK, 4TH EDITION

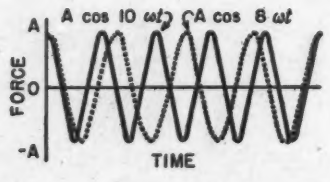


FIGURE. 7 - GRAPHICAL REPRESENTATION OF FORCE CAUSING HARMONIC VIBRATION

REFERENCE - FREBERG & KEMLER: ELEMENTS OF MECHANICAL VIBRATION

Damping is undesirable for ratios greater than 1.414 unless the disturbing force is of such a variable frequency, that the ratio may approach one during a portion of the operation. In this case, a damping device must be used. It can be adjusted to come into action only in case the amplitude of the transmitted force exceeds a certain value.

Figure 10 shows for various disturbing frequencies and percentage reduction of force, the natural frequency required of the elastic support, and also the amount which the support must deflect statistically when loaded with the machine which it is desired to isolate.

The theory of elastic engine supports has been discussed at length

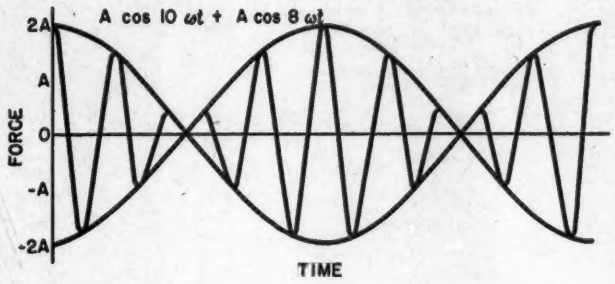


FIGURE 8 - BEAT FREQUENCY RESULTING FROM SIMULTANEOUS ACTION OF FORCES SHOWN IN FIGURE 7

REFERENCE - FREBERG & KEMLER· ELEMENTS OF MECHANICAL VIBRATION

in a paper by Rosenzweig. [14]

As an alternate to isolating engines from the piping, piping can be isolated from the engines. If it is necessary to support piping from the engine foundations or from structures affected by engine vibrations, elastic piping supports can be used. These may be steel springs if the piping is suspended from a structure, and steel springs or rubber if the piping is supported from the foundation.

In this latter case, the piping can also be protected from pressure waves transmitted from the foundation by causing a portion of the force of the wave to be reflected back into the foundation. This is accomplished by interposing between the support and the foundation a layer of material in which the velocity of sound is low as compared to the velocity of sound in concrete. Examples of such materials are rubber, cork, and dry sand. If rubber is used approximately eighty per cent of the force will be reflected back into the concrete.

The problem of isolating pipe bends from changes in velocity of the flowing fluid is more difficult. Some degree of uniformity of flow in the lines to and from the compressors may be attained by the use of apparatus similar to that used to muffle the exhaust from an engine. However, the problem is more difficult. A muffler attempts only to suppress vibrations in the audible sound range while here we are concerned with securing a constant flow velocity. It may be possible to solve the problem by acoustical methods. [16]

The third and final avenue of approach is careful, intelligent piping design. Supports should be spaced so that no part of the piping system has its natural frequency of vibration equal or nearly equal to the frequency of any periodic force created by the engine or compressor. As was noted in the discussion of Figure 6, if the supports are spaced so that the ratio of the frequency of the disturbing force to the natural frequency of the piping is greater than 1.4, magnification factors of less than one can be obtained. This will result in piping which will be almost free of vibration. A disadvantage of designing for ratios in this range is that when an engine is shut down, at some instant before it comes to rest, the frequency of the forces which it emits will be in resonance with the piping. This might cause destructive vibration. While this difficulty can be overcome by installing vibration dampners on the piping, it is probably safer practice to design for ratios of between 0.25 and 0.50, even though this results in magnification factors slightly greater than one.

Particular attention must be given to supporting piping at points where changes in direction occur. At these points, the piping is subject to both the forces eminating from the engine and those set up by the pulsating flow of gas from the compressor cylinders. In case the change in direction is installed for the purpose of securing flexibility, it may be necessary to use springs or other types of elastic supports.

It might be possible to eliminate

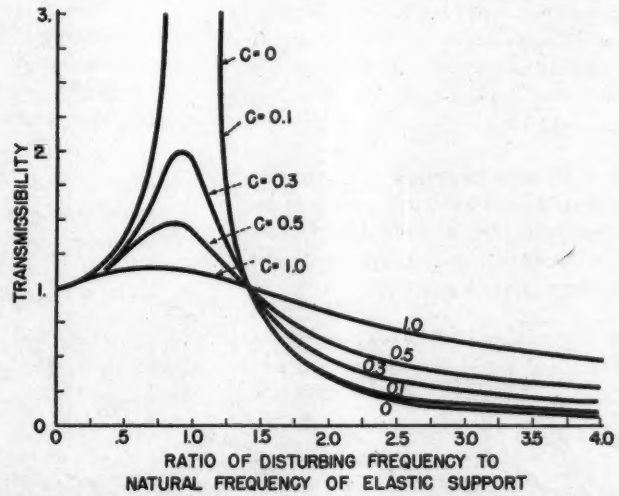


FIGURE. 9 - TRANSMISSIBILITY OF ELASTIC SUPPORTS

REFERENCE - FREBERG & KEMLER: ELEMENTS OF MECHANICAL VIBRATION

Type "OSS" for soft, sticky formations
Type "OS" for shale and medium sand rock
Type "OW" for medium hard shale
Type "O" for ordinary surface formations
Type "CO" for abrasive limes and shales
Type "C" for hard and abrasive formations
Type "CF" for extremely hard formations
Type "OWS" for medium hard shales and sandy shale of softer layers

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vibration in expansion bends if they were designed to be symmetrical about an axis coincident with that of the main pipe line. In this case components of pressure in all directions, except the original direction of flow, would neutralize each other.

Lengths of piping between the compressor cylinder and the surge chamber or header, and between surge chamber and header, or between headers, should not be equal to the resonant length for the frequency at which gas pulsates in the line. If resonant lengths cannot be avoided, the magnitude of the standing pressure wave formed can be limited by installing a condenser or surge chamber in the line near the compressor cylinder. The required volumetric capacity of the condenser is a function of the piston displacement of the cylinder, the normal pressure in the line, and the permissible pressure rise.[15]

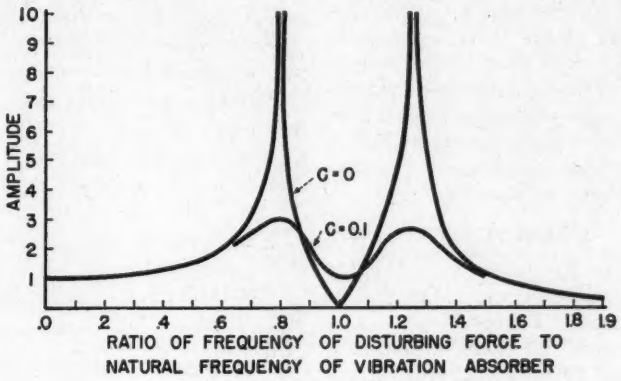


FIGURE. II - EFFECT OF DYNAMIC VIBRATION ABSORBERS

REFERENCE - FREBERG & KEMLER: ELEMENTS OF MECHANICAL VIBRATION

Now, even the best of engineers sometimes make mistakes. Either errors of omission, or the other kind. So it is always well to have a few aces up the sleeve just in case there is a joker somewhere in the design. The standard method of dealing with a vibrating pipe is to install more supports and more and heavier pipe clamps. This is equivalent to increasing the natural frequency of vibration of the piping. The natural frequency of vibration of a section of piping can also be increased by attaching a spring to it. The spring is selected and loaded so that the natural frequency of the spring, load, and piping is sufficiently greater than the disturbing frequency to reduce the magnification factor by the required amount.

Another approach as indicated by the Magnification Factor Chart, Figure 6, is to reduce the number of supports. In this way magnification factors of less than one can be obtained. The hazards of this approach should be kept in mind when it is used.

The amplitude of the vibration can also be limited by the installation of damping devices such as hydraulic shock absorbers or friction type snubbers.

Another effective means of reducing vibration in piping is the use of dynamic vibration absorbers. These consist of a weight suspended on an elastic member from the vibrating piping. The natural frequency of the weight and elastic suspension should be the same as the natural frequency of the vibrating member. The relationship between the amplitude of the vibration of the original member in such a system and the ratio of the frequency of the disturbing force to the natural frequency of the compensating systems is shown in Figure 11 for zero damping and for a damping coefficient of 0.10. Inspection of the figure shows that the device cannot be used if the range of disturbing frequencies is too great.

Those remarks practically conclude the paper. Some of you, no doubt, would have appreciated a mathematical presentation of the subject. This was purposely avoided because the mathematics is fully developed in books dealing with special phases of the subject. These books and some of the formulas to

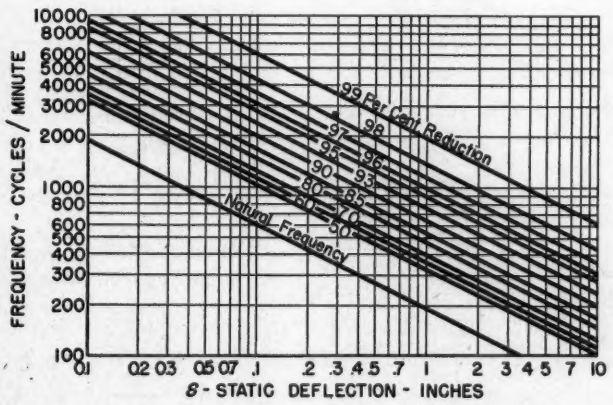


FIGURE. 10 - VIBRATION ISOLATION FREQUENCY - STATIC DEFLECTION CHART

REFERENCE - FREBERG & KEMLER: ELEMENTS OF MECHANICAL VIBRATION

be found therein are listed in the appendix.

The principal aim of the paper has been to give you a Cook's tour prospectus of the three avenues of approach to the problem of designing compressor plants which will be free of troublesome piping vibration. It will have been accomplished if you have been encouraged to further explore these approaches.

## FORMULAS

A. Fatigue Strength

Reference—Johnson: Materials of Construction, Chapter 28.

A formula for determining the maximum permissible unit stress during a cycle is as follows:

$$S_{max} = \frac{0.5\ S_u}{1 - 0.5_r}$$

$S_u$ = Ultimate tensile strength of the material.

$_r$ = Ratio of minimum to maximum stress during the cycle.

$S_u$ can be replaced by $S_w$.

$$S_w = \frac{S_u}{\text{Factor of Safety}}$$

Another formula, developed on a different basis is as follows:

$$S_{max} = \frac{2\ S_1}{(1 - r) + S_1\ (1 + r)}{S_y}$$

$S_1$ = The endurance limit for completely reversed stresses.

$S_y$ = Yield strength.

B. Vibration.

Reference — Freberg & Kemler Elements of Mechanical Vibration.

1. Free Harmonic Vibration.

The natural frequency of vibration ($f_n$) of a mass suspended from a spring of negligible mass is

$$f_n = \frac{1}{2\pi}\sqrt{\frac{Kg}{W}}$$

K = Spring constant (lb.)/(in.).

g = Acceleration (in.)/(Sec.)$^2$ due to gravity.

W = Weight (lbs.)

$\pi$ = 3.1416

$f_n$=Natural frequency of vibration, cycles per second.

The spring constant (K) for two springs in parallel and having constant $K_1$ and $K_2$, respectively is

$K = K_1 + K_2$

If the same springs operate in series, the constant (K) for the system is

$$K = \frac{K_1\ K_2}{K_1 + K_2}$$

The spring constant is further defined as

$$K = \frac{F}{d} = \frac{W}{d}$$

F = Force in pounds acting on spring.

d = Deflection of spring in inches.

$$d = \frac{W}{K}$$

$$\frac{K}{W} = \frac{1}{d}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{g}{d}}$$

The natural frequency of vibration of a beam, such as a pipe between supports, can be approximated by computing the maximum deflection due to its own weight and substituting in the above formula. For an exact method see Timoshenko: Vibration Problem in Engineering.

2. Forced Damped Vibration.

If a periodic force acts upon a system susceptible to vibration, the amplitude of the resulting vibration is

$$X = \frac{F}{K}\left\{\frac{1}{\left[\left(1 - \left(\frac{V}{W_n}\right)^2\right)^2 + \left(2\ C\ \frac{V}{W_n}\right)^2\right]^{1/2}}\right\}$$

X = Amplitude of the forced vibration.

V = Frequency of the disturbing force (radians per second).

$W_n = 2\pi f_n$ radians per second.

C = Coefficient of damping = Ratio of actual damping to critical damping.

$$\text{Critical Damping} = 2\frac{W}{g}W_n$$

the term

$$\frac{1}{\left[\left(1 - \left(\frac{V}{W_n}\right)^2\right)^2 + \left(2\ C\ \frac{V}{W_n}\right)^2\right]^{1/2}}$$

is called the magnification factor and is shown in Figure 6.

3. Elastic Supports.

If a vibrating machine is supported on a sub-structure by an elastic medium, the ratio of the force transmitted to the substructure to the disturbing force is

T. R. = Tranmissibility = Ratio of force transmitted to substructure to disturbing force. This relationship is shown graphically in Figure 9.

4. Dynamic Vibration Absorber.

If a body is vibrating it is pos-

$$T.R. = \left[\frac{1 + \left(2C\ \frac{V}{W_n}\right)^2}{\left(1 - \left(\frac{V}{W_n}\right)^2\right)^2 + \left(2C\ \frac{V}{W_n}\right)^2}\right]^{1/2}$$

sible to reduce or eliminate the vibration by suspending from the vibrating body a weight supported by an elastic member. If $W_1$ and $K_1$ represent the weight and spring constant of the system in which the vibration is occurring and $W_2$ and $K_2$ represent the weight and spring constant of the system suspended from it to control the vibration, then the amplitude of the movement of $W_1$ is as follows:

$$X_1 = \frac{F}{K_1}\left\{\frac{1-\left(\frac{V}{W_{n_2}}\right)^2}{\left[1-\left(\frac{V}{W_{n_2}}\right)^2\right]\left[1+\frac{K_2}{K_1}-\left(\frac{V}{W_{n_1}}\right)^2\right]-\frac{K_2}{K_1}}\right\}$$

$$W_{n_1} = \left(\frac{K_1 g}{W_1}\right)^{1/2}$$

$$W_{n_2} = \left(\frac{K_2 g}{W_2}\right)^{1/2}$$

This function is shown graphically in Figure 8. When $V = W_{n_2}$, the amplitude of the motion of $W_1$ may be reduced to zero by making $\frac{K_2}{W_2} = \frac{K_1}{W_1}$, or since $\frac{K}{W} = \frac{1}{d}$, this may also be expressed as $\frac{1}{d_2} = \frac{1}{d_1}$.

The amplitude of motion of $W_2$ is

$$X_2 = \frac{F}{K_1}\left\{\frac{1}{\left[1-\left(\frac{V}{W_{n_2}}\right)^2\right]\left[1+\frac{K_2}{K_1}-\left(\frac{V}{W_{n_1}}\right)^2\right]-\frac{K_2}{K_1}}\right\}$$

C. Propagation of Pressure Waves.

Reference—Thornton: Mechanics Applied to Vibration and Balancing, Chapter 4.

The rate of propagation of pressure waves through an elastic medium is

$$a = \left(\frac{E g}{d}\right)^{1/2}$$

a = Rate of propagation of disturbance is (ft.)/Sec.

E = Modulus of Elasticity of medium (lbs.)/(ft.)$_2$

g = Acceleration of gravity (ft.)/(Sec.)$_2$

d = Density (lbs.)/(ft.)$_3$

This is sensibly the velocity at which sound is propagated in the material.

At the interface between two materials having dissimilar values of a, a portion of the stress due to pressure waves will be reflected back. If $P_A$ is the stress due to the original wave, then the reflected stress will be

$$P_B = \left[\frac{(E_2 d_2)^{1/2} - (E_1 d_1)^{1/2}}{(E_2 d_2)^{1/2} + (E_1 d_1)^{1/2}}\right] P_A$$

the transmitted stress is

$$P_C = \frac{2 P_A}{1+\left(\frac{E_1 d_1}{E_2 D_2}\right)^{1/2}}$$

Subscript 1 refers to the medium from which the stress is being transmitted. Subscript 2 refers to the medium to which the stress is being transmitted. A negative value indicates that the reflected or transmitted stress produces a state of tension.

D. Pressure Due to Deviated Flow.

Reference — Marks: Mechanical Engineers Handbook, 4th Edition, Page 279.

If the direction of flow of a stream is changed, the pressure or thrust in the direction before turning is

P = (Qw V/g) (1 - cosB)

Q = Quantity flowing per second.

w = Weight of unit volume of fluid.

V = Velocity of fluid.

g = Gravity acceleration constant.

B = Angle thru which flow is deviated, measured from direction before turning.

The total resultant pressure is

$$P = (QwV/g)\left[2(1-\cos B)\right]^{1/2}$$

The direction of the resultant force is 90° from midway between the original and final direction of the flowing liquid.

E. Resonant Length of Pipes.

Reference—Olson: Elements of Acoustical Engineering, Page 47.

The fundamental resonant frequency of a pipe open at both ends is

$$f = \frac{a}{2L}$$

If the pipe is closed at one end

$$f = \frac{a}{4L}$$

f = resonant frequency in cycles per sec.

a = velocity of sound in gas in ft. per sec.

L = Length of pipe in feet.

In the case of a pipe closed at one end, such as between a compressor cylinder and surge chamber or header, lengths corresponding to the fundamental frequency should be avoided, and if possible the second harmonic.

In the case of a pipe open at both ends, such as between a surge chamber and a header, or between two headers, lengths corresponding to the fundamental and, if possible, the third harmonic, should be avoided.

F. Weight of Foundation.

Reference—Slocum: Noise and Vibration Engineering, Page 44.

The weight of a foundation which will result in a given amplitude of the lateral motion b of a foundation and reciprocating machine of horizontal type is given as follows:

$$W_4 = \frac{r}{b(1+K)}\left[W_1 + W_2\left(1+\frac{1}{q}\right)\right] - \frac{W_3}{1+K}$$

$W_4$ = Weight of foundation.

$W_3$ = Total dead weight of engine—lbs.

*(Continued on Page 19)*

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## Vibration in Compressor Plant Piping

*(Continued from Page 17)*

$W_2$ = Weight of reciprocating parts—lbs.

$W_1$ = Weight of eccentric rotating parts—lbs.

r = Crank radius in inches.

b = Amplitude of vibrating motion—inches.

q = Length of connecting rod/length of crank.

k = Ratio of mass of soil accelerated to mass of foundation. In the example given, the factor was assumed to be 10.

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## Carrington King

*(Continued from Page 3)*

a crisis develops. Contracts already have been sent the companies and the crude is expected to start rolling in by rail within the next week or two.

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The furious tempo of the war in Europe and increasing activity in the Pacific already have shot up military demands for 100-plus octane gasoline to an alarming new high. While the East Coast will be the principal sufferer in the shortage that is looming, dislocations all along the line may be expected.

Demand for military petroleum products is up 500,000 barrels a day over what it was a year ago, according to Davies, who issued a warning to East Coast civilians on the tight situation that will prevail in gasoline and heating oils this winter. Transportation facilities along the Atlantic seaboard already have been affected and every effort is being made to increase barge and pipeline transportation to offset commandeering of tankers from that area by the military and the rerouting of tank cars to the most critical areas.

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Importation of Persian crude to the West Coast of America, clear across the Pacific Ocean, is a post-war possibility receiving some attention from the industry.

While the cost of such a program would depend on the maintenance of the present 21½¢ tariff and the price of crude in the U. S., it is conceded that such shipments would be more feasible than transporting Persian crude to the Atlantic Coast. High toll-charges established by the French at the Suez Canal would prevent an economic trade between Arabia and the U. S., it is pointed out, whereas the longer trans-Pacific journey would save canal fees.

. . . Development in Saudi Arabia is progressing rapidly, it is reported, with 27 wells producing at Dammam and five at Abqaiq. Two wells have been completed this year by the Arabian-American Oil Co. and numerous wells plugged during the war period are being rehabilitated and will be back in production at the end of the year. Production is approximately 100,000 B/D.

Relations between American companies and the Arabian Government "couldn't be more harmonious", CALIFORNIA OIL WORLD was told. Regarding recent disturbances in northern Iran—caused by Russia's belated demands for concessions—it has been reliably reported that the principal concern of Russia is the safeguarding of her borders, rather than a desire to acquire oil. The five northern provinces of Iran, where trouble has occurred, are adjacent to Russia's frontiers, it was pointed out, and are not particularly productive.

The cry that the Office of Price Administration's price policy is "driving the independent petroleum producer out of business" was raised again in Congress by the House Committee on Small Business in an interim report unanimously adopted by the members.

Recommending appointment by the OPA of an "Industry Advisory Committee" — on a nation-wide basis and with independents given representation "proportionate with their percentage of national production and of the number of firms engaged in that business" - - - Chairman Wright Patman (D., Tex.) and his committee scolded OPA for relying on a U. S. Tariff Commission report, made in 1942, as its principal source of information regarding crude oil production costs—although "this report's correctness has been effectively challenged by the industry".

An "up-to-date study" of operating costs was called for by the committee and OPA was reminded that it should "take greater cognizance of the role of the independent and other producers in the field of exploration and should include amortization of exploration costs as part of the permissible costs used as a basis for calculating price ceilings on crude oil. . . . A premium price plan for stripper wells should be maintained if such an increase in the over-all price is put into effect.

If protection against wear of joints, collars and casing is to be effective, a Patterson-Ballagh Protector must be used at *each* tool joint: Even *one* unprotected joint (which means a Protector missing or worn below the tool joint diameter) may mean water intrusion five years from today or sooner.

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# PATTERSON-BALLAGH PROTECTORS

# Pressure---Volume---Temperature and Solubility Relations for Natural Gas---Water Mixtures

By C. R. Dodson and M. B. Standing
Standard Oil Company of California
La Habra, California

**Abstract**

Pressure—volume — temperature and solubility data are presented for mixtures of natural gas and water and for mixtures of natural gas and two typical oil field brines. The data permit estimations of the solubility of gas in reservoir interstitial waters and of the amount of water vapor present in the free gas phase of the reservoir. The compressibility and formation volume of the gas-saturated interstitial water are given as functions of the gas solubility.

The investigation covered pressures from 500 to 5000 PSIA; temperatures from 100° F. to 250° F.; and water or brines having up to 35,000 parts per million total solids.

**Introduction**

Field and laboratory experience have established that interstitial or connate water and natural gas coexist in varying amounts in most oil sands. Therefore, under reservoir conditions it would be expected that gas would exist in solution in the interstitial water. Also, that water vapor would be present in the free gas phase of the reservoir.

A consideration of the above statements introduces questions such as the following:

(1) What is the magnitude of the solubility of natural gas in the interstitial water under reservoir pressures, temperatures and water salinities and how does it change with pressure decline?

(2) What are the formation volume changes in the interstitial water during the pressure decline in the reservoir?

(3) What is the compressibility of the saturated interstitial water and how does it vary with pressure decline?

(4) Since water vapor exists in the reservoir gas phase, can it account for the water production from "clean" gas wells or high gas-oil ratio wells?

The work described in this paper was undertaken to provide data on natural gas and water mixtures which could be used to answer questions such as the above.

From the solubility relations of comparable binary systems report-

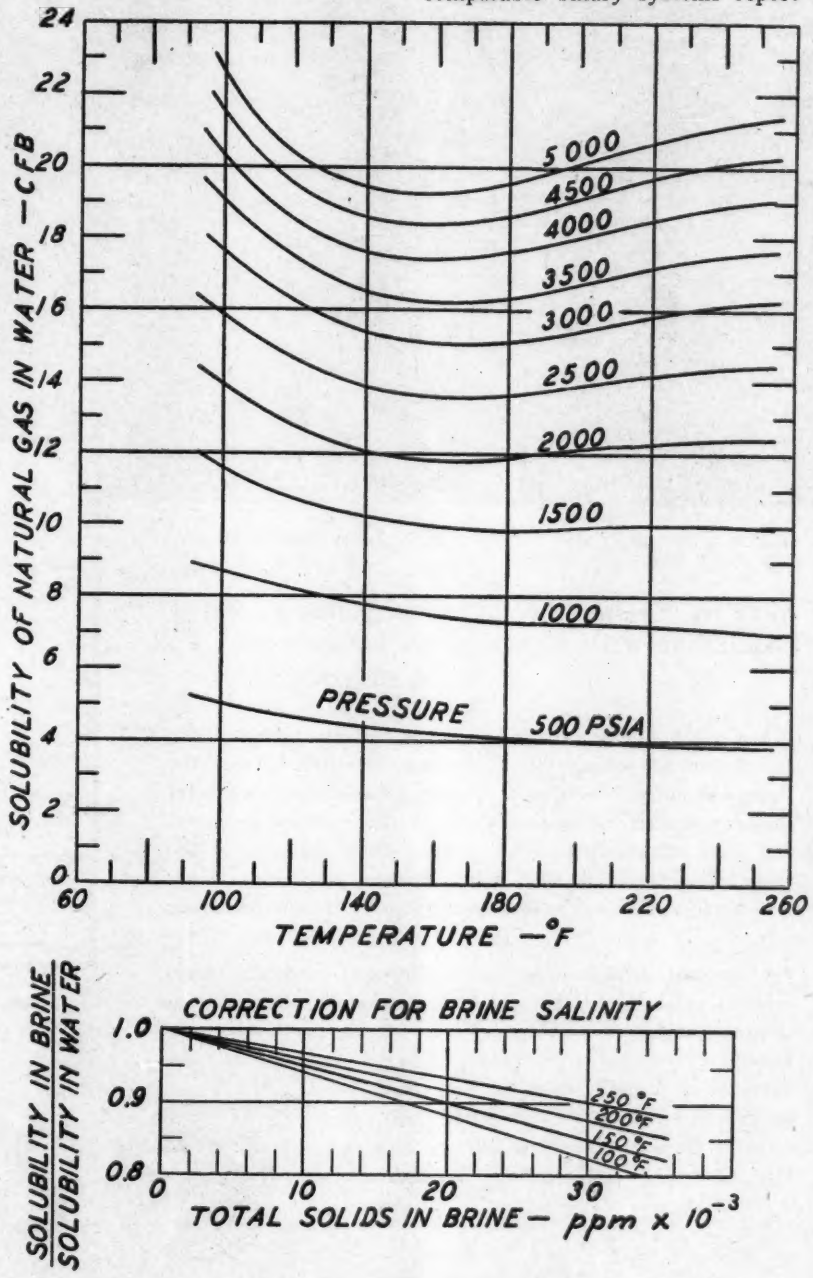



FIG. 1 SOLUBILITY OF NATURAL GAS IN WATER

**TABLE III**
**SOLUBILITY OF NATURAL GAS IN WATER AND BRINE**
**Solubility—Cubic Feet per Barrel**

| Pressure PSIA | 100°F. | 150°F. | 200°F. | 250°F. |
|---|---|---|---|---|
| | Natural Gas-Distilled Water | | | |
| 5000 | 22.5 | 19.3 | 20.1 | 21.3 |
| 4500 | 21.5 | 18.5 | 19.2 | 20.2 |
| 4000 | 20.3 | 17.5 | 18.0 | 19.0 |
| 3500 | 19.0 | 16.3 | 16.7 | 17.6 |
| 3000 | 17.6 | 15.2 | 15.4 | 16.2 |
| 2500 | 15.8 | 13.7 | 13.9 | 14.4 |
| 2000 | 13.9 | 11.9 | 12.1 | 12.4 |
| 1500 | 11.6 | 10.1 | 10.0 | 9.9 |
| 1000 | 8.7 | 7.6 | 7.2 | 7.0 |
| 500 | 5.0 | 4.3 | 4.0 | 3.8 |
| | Natural Gas—Brine "A" | | | |
| 5000 | 21.3 | 18.5 | 19.2 | |
| 4500 | 20.0 | 17.7 | 18.3 | |
| 4000 | 19.2 | 16.8 | 17.2 | |
| 3500 | 17.9 | 15.6 | 16.0 | |
| 3000 | 16.5 | 14.6 | 14.6 | |
| 2500 | 15.0 | 13.1 | 13.2 | |
| 2000 | 13.2 | 11.4 | 11.4 | |
| 1500 | 11.0 | 9.7 | 9.3 | |
| 1000 | 8.4 | 7.3 | 6.8 | |
| 500 | 4.8 | 4.1 | .... | |
| | Natural Gas—Brine "B" | | | |
| 5000 | 18.3 | 16.0 | 17.6 | |
| 4500 | 17.4 | 15.4 | 16.7 | |
| 4000 | 16.5 | 14.5 | 15.7 | |
| 3500 | 15.3 | 13.5 | 14.6 | |
| 3000 | 14.2 | 12.6 | 13.2 | |
| 2500 | 12.7 | 11.4 | 11.9 | |
| 2000 | 11.2 | 9.9 | 10.3 | |
| 1500 | 9.3 | 8.4 | 8.4 | |
| 1000 | 6.8 | 6.3 | 6.0 | |
| 500 | .... | .... | .... | |

Brine "A" contains 8,630 ppm total solids.
Brine "B" contains 34,100 ppm total solids.

at each pressure point. Between the analyses the cell contents were vigorously stirred in order to insure phase equilibrium. The gas volumes obtained were corrected to dry gas at 60° F. and 14.7 PSIA. The weights of water obtained were corrected to volumes at 60° F. The resulting solubilities are expressed as cubic feet of dry gas at 60° F. and 14.7 PSIA per barrel of liquid.

In determining the solubility of water vapor in the natural gas the usual method of passing a sample of the vapor phase through a glass trap immersed in a dry-ice-acetone bath resulted in condensing out the heavier components of the natural gas in the trap. The method used, therefore, was to remove a portion of the equilibrium vapor from the cell, pass the sample at atmospheric pressure and temperature through a U-tube containing Dehydrite, and to collect the resulting dry natural gas in evacuated bottles. By weighing the Dehydrite tube before and after the withdrawal process, and determining the amount of dry natural gas collected in the bottles, the relative proportions of the two in the equilibrium vapor could be determined. The resulting solubility of water vapor in the natural gas is expressed as barrels of liquid water at 60° F. per million cubic feet of dry natural gas measured at 60° F. and 14.7 PSIA.

The compressibilities of several natural gas-water and natural gas-brine mixtures at pressures above their bubble point pressures, and the volume occupied by the mixtures at their bubble points were determined by starting at pressures several thousands of pounds above the bubble points of the mixtures, removing successively small portions of mercury from the cell and observing the resulting change in pressure. In determining the pressure-volume changes of the natural gas-distilled water mixtures direct readings of the mercury level within the cell were made electrically. This type of measurement could not be made for the brine mixtures so that their volume changes were computed from the weights of mercury withdrawn from the cell.

**Results**

The results of the experimental

**TABLE IV**
**FORMATION VOLUMES OF PURE WATER AND MIXTURES OF NATURAL GAS AND WATER**
**Formation Volumes—Barrel per Barrel**

| Saturation Pressure PSIA | 100°F. | 150°F. | 200°F. | 250°F. |
|---|---|---|---|---|
| | Natural Gas and Water | | | |
| 5000 | 0.998[9] | 1.012[6] | 1.030[1] | 1.052[2] |
| 4000 | 1.000[3] | 1.014[0] | 1.031[6] | 1.053[7] |
| 3000 | 1.001[7] | 1.015[4] | 1.033[0] | 1.055[3] |
| 2000 | 1.003[1] | 1.016[8] | 1.034[5] | 1.056[8] |
| 1000 | 1.004[5] | 1.018[3] | 1.036[1] | 1.058[4] |
| Pressure PSIA | Pure Water[3] | | | |
| 5000 | 0.991[0] | 1.003[9] | 1.021[9] | 1.041[8] |
| 4000 | 0.993[8] | 1.006[7] | 1.024[6] | 1.045[3] |
| 3000 | 0.996[6] | 1.009[5] | 1.027[1] | 1.048[7] |
| 2000 | 0.999[5] | 1.012[5] | 1.030[4] | 1.052[3] |
| 1000 | 1.002[5] | 1.015[3] | 1.033[5] | 1.056[9] |
| Vapor Pressure of Water | 1.005[5] | 1.018[7] | 1.037[0] | 1.059[8] |

**TABLE V**
**SOLUBILITY OF WATER IN NATURAL GAS**
**Solubility—Barrels per 1000 MCF Dry Gas**

| Pressure PSIA | 100°F. | 150°F. | 200°F. | 250°F. |
|---|---|---|---|---|
| 5000 | 0.070 | 0.23 | 0.62 | 1.46 |
| 4500 | 0.072 | 0.24 | 0.66 | 1.55 |
| 4000 | 0.075 | 0.25 | 0.70 | 1.65 |
| 3500 | 0.081 | 0.27 | 0.75 | 1.80 |
| 3000 | 0.087 | 0.30 | 0.82 | 1.99 |
| 2500 | 0.095 | 0.33 | 0.93 | 2.26 |
| 2000 | 0.11 | 0.38 | 1.08 | 2.70 |
| 1500 | 0.13 | 0.46 | 1.36 | 3.40 |
| 1000 | 0.17 | 0.64 | 1.90 | .... |
| 500 | 0.31 | 1.17 | 3.60 | .... |

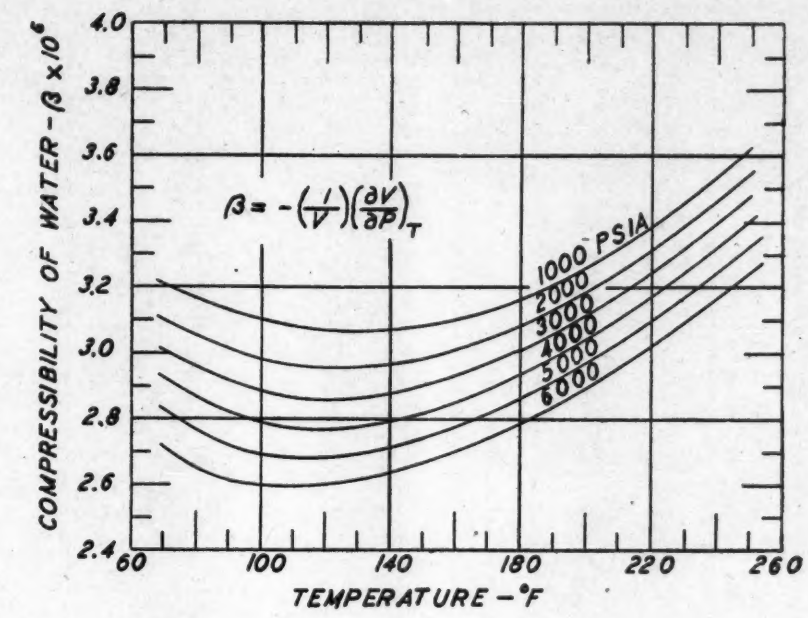
tests are shown in the following tables and figures. The basis of the solubility and volumetric data is barrels of liquid water at 60° F. and cubic feet of dry natural gas measured at 60° F. and 14.7 PSIA.

In Table III are tabulated the solubilities of the natural gas in distilled water and in the two oil field brines at various temperatures. The values at the pressures shown are smoothed from large scale plots.

Figure 1 is a plot of the data presented in Table III. The upper plot is the solubility data for the natural gas in distilled water while the lower plot is a general correction factor to account for the decreased solubility of the natural gas in the two brines. It should be realized that the correction factors presented in Figure 1 are approximate and should apply only to brines having characteristics similar to those in Table II.

The formation volumes of the pure water and natural gas-water mixtures are tabulated in Table IV. Although the results for natural gas-water presented in Table IV were determined for bubble point conditions, it is expected that they would represent quite closely the formation volumes of the saturated liquids. Also, while it was not possible to directly measure the formation volumes of the brine solution, it is believed that Table IV can be used to estimate these values provided allowances are made for the decreased solubility of the gas in brines.

Figure 2 presents a method for determining the compressibilities of the natural gas-water and natural gas-brine mixtures at pressures above their bubble point pressures. The upper plot is the compressibility of water computed from the data of Keenan and Keyes (3). The lower plot shows the increase in compressibility of the liquid phase due to the solution of natural gas. The test data indicated no appreciable difference between the compressibilities of the natural gas-water mixtures and the natural gas-brine mixtures.



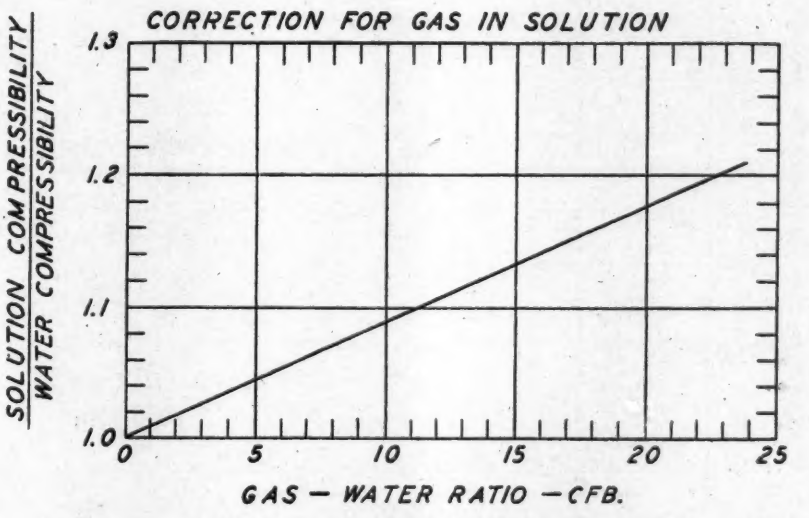




FIG. 2 EFFECT OF DISSOLVED GAS UPON THE COMPRESSIBILITY OF WATER

### Application of Results

To illustrate the use of the solubility and volumetric data described above, suppose that it is desired to calculate the properties of the formation gas and the interstitial water in a reservoir at 3000 PSIA and 200° F. It is assumed that the gas and water are similar to those used in the tests and that the interstitial water has a salinity of 30,000 parts per million.

From Table III the solubility of the gas in pure water is found to be 15.4 CFB. From Figure 1 the correction factor for 30,000 ppm salinity is 0.88, hence the corrected solubility of the gas in the interstitial water is 15.4 x 0.88 or 13.6 CFB.

If the reservoir pressure declines to 2000 PSIA the amount of gas in solution is reduced to 10.6 CFB. Hence, 13.6 minus 10.6 or 3 CFB of natural gas are released from solution.

To calculate the properties of the interstitial water in the reservoir, it is observed from Table IV that the change in formation volume of pure water at 3000 PSIA and 200° F. due to the solution of 15.4 CFB of gas is 1.0330 minus 1.0271 or 0.0059 barrels per barrel. Since the solu-

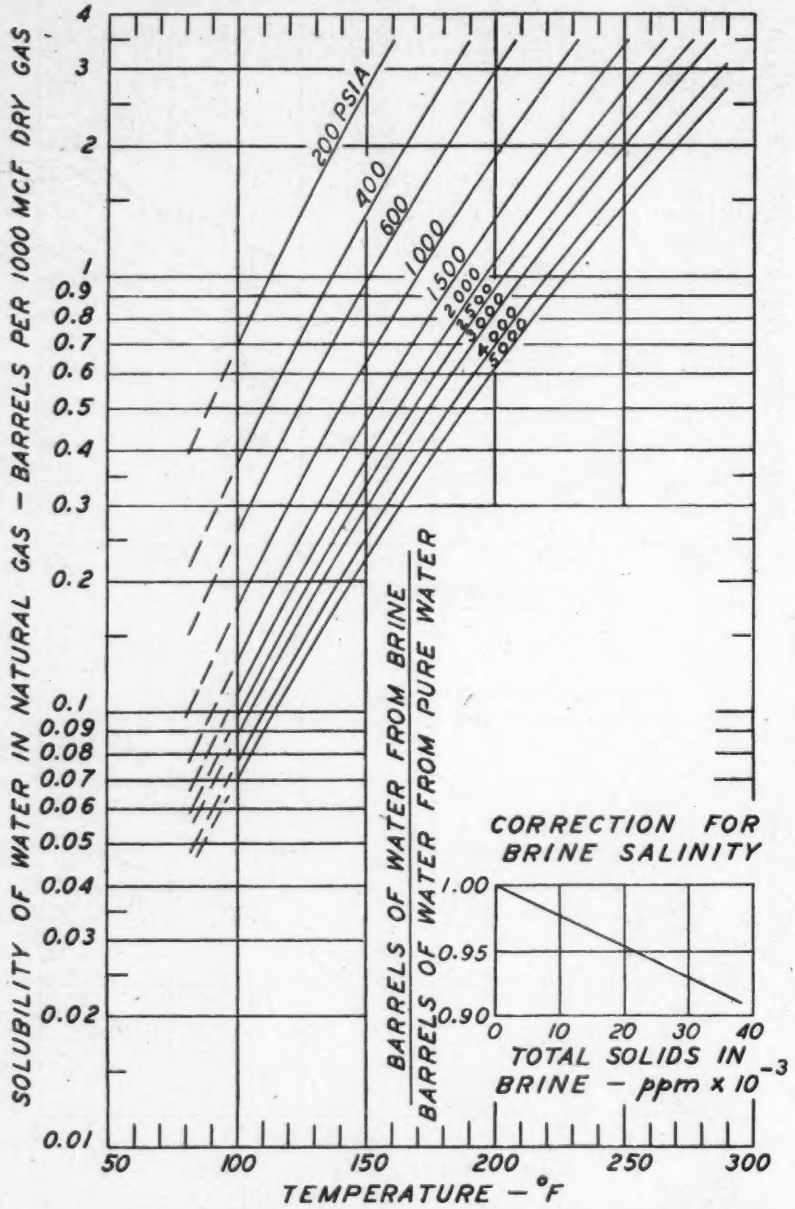



*FIG. 3 EFFECT OF PRESSURE & TEMPERATURE UPON THE SOLUBILITY OF WATER IN NATURAL GAS*

bility in the interstitial water is only 13.6 CFB, the change in formation volume would be expected to be 13.6/15.4 x 0.0059 or 0.0052. Hence, the formation volume of the interstitial water is calculated to be 1.0271 plus 0.0052 or 1.0323 barrels per barrel. A similar calculation at a reservoir pressure of 2000 PSIA yields a formation volume of 1.0340 barrels per barrel, which indicates that even though the interstitial water contains less dissolved gas at 2000 PSIA than it did at 3000 PSIA its volume is greater at the lower pressure. This result is interesting because it is opposite to the behavior of natural gas-crude oil mixtures.

The compressibility of the saturated interstitial water is found from Figure 2 by multiplying the correction factor for the gas solubility, 1.12 for a 13.6 CFB mixture, times the compressibility, 3.12 x $10^{-6}$, of pure water which gives 3.50 x $10^{-6}$ barrels per barrel per pound per square inch.

The use of data on the formation volumes of the saturated interstitial water together with the data on the compressibilities permit accurate accounting of the interstitial water behavior for material balance calculations where the accuracy of the other data justifies the additional refinement.

Water production from so-called "clean" gas wells or high gas-oil ratio (distillate) wells may be a combination of the water that exists as vapor in the reservoir gas and liquid water that is brought to the surface by mechanical entrainment in the gas. The water produced by condensation is free of salts while the entrained water may contain considerable amount of dissolved salts.

The amount of water that will be produced from a well as vapor can be determined from Table V and Figure 3. For example, consider the case of a gas reservoir at 3000 PSIA and 200° F. in which the interstitial water has a salinity of 30,000 parts per million. From Table V and Figure 3, the amount of water vapor in the formation gas is shown to be 0.82 barrels per 1000 MCF of dry gas when vaporized from pure water, or 0.82 x 0.93 which equals 0.76 barrels per 1000 MCF for the gas in equilibrium with the saline interstitial water. If the foregoing reservoir gas is put through a trap operating at 500 PSIA and 100° F., the amount of water which can remain as vapor in the gas at these conditions is shown in Table V to be 0.31 barrels per 1000 MCF. Hence, the difference, 0.76 minus 0.31 or 0.45 barrels per 1000 MCF, will be condensed to liquid water and accumulate in the trap.

It will be noticed from Figure 3, that if the surface trap is operating at 200 PSIA and 100° F., then practically none of the water vapor produced from the well would condense in the trap.

When the water produced at the surface contains appreciable quantities of salts and amounts to considerably more than that indicated by these charts and tables it is good evidence that edge or bottom water is coming into the well.

**Summary**

The results of the investigation may be summarized as follows:

(1) The solubility of natural gas in connate or interstitial water may amount to as much as 20 cubic feet per barrel at 5000 PSIA in the temperature range of oil reservoirs.

(2) The solubility of natural gas in brine decreases with increasing total solids content. A brine having a total solids content of 30,000 ppm will have only about 90 per cent as much gas dissolved in it at 5000 PSIA and 200° F. as will fresh water at the same pressure and temperature.

(3) The compressibility of the saturated liquid phase is increased about 18 per cent by the solution of 20 cubic feet of gas per barrel of water.

(4) The amount of water in the gas phase is dependent on the pressure, temperature, and the salinity of the brine from which the water was vaporized. At 5000 PSIA and 200° F., the concentration of the water in the natural gas amounts to approximately 0.6 barrels per 1000 MCF of dry gas. If the water has been vaporized from a brine having a total solids content of 30,000 ppm, the concentration is decreased, about 7 per cent to 0.57 barrels per 1000 MCF.

**Acknowledgment**

This work has been carried out as a part of a general program of experimental study of naturally occurring hydrocarbon mixtures. The authors wish to express their appreciation to the Standard Oil Company of California, particularly to Mr. E. G. Gaylord, for permission to publish the material in this paper. The authors are grateful to the staff members of the Production Technology Laboratory for their assistance in compiling this paper.

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**Presented at Spring Meeting of the Pacific Coast District of the American Petroleum Institute, Los Angeles, California**

## Tide Water Associated Oil Announces Organizational Changes

W. A. Reanier, Domestic Sales Manager of Tide Water Associated Oil Company, announces that Fred G. Stolle has been promoted to the position of Supervisor of Special Products Sales for the Company's Western Division, and will be transferred from the Los Angeles District to the Company's headquarters in San Francisco. Mr. Stolle has been Sales Agent for Tide Water Associated at Burbank, following a series of promotions since he started with the Company eleven years ago.

E. C. Heinz, District Sales Manager for Tide Water Associated in Southern California, announces that James C. Kilgore, who has been Sales Agent at San Pedro, will succeed Fred Stolle as Sales Agent at Burbank. L. W. Becker is promoted from District Specialty Salesman to Sales Agent at San Pedro. Frank J. Cazey is promoted from Commercial Salesman at Vernon to District Specialty Salesman, headquartering at the Los Angeles District office.

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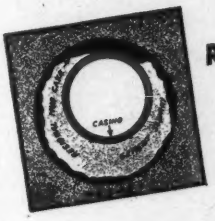


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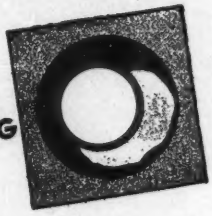

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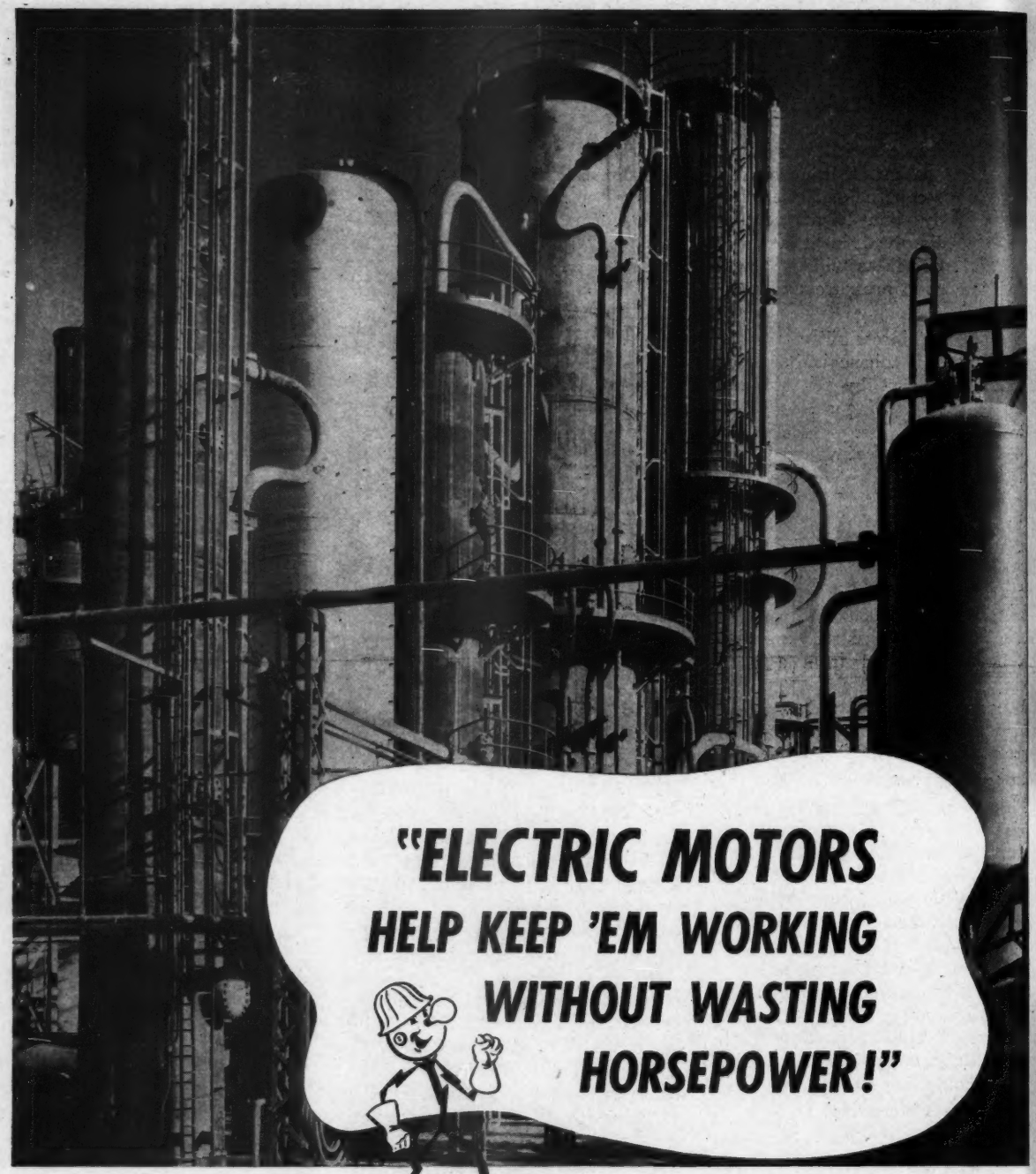


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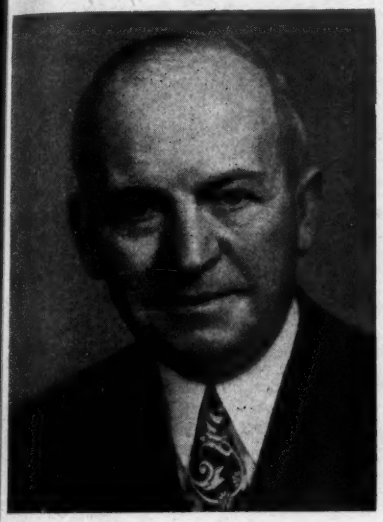
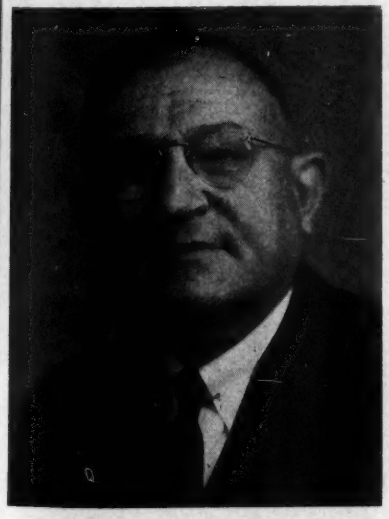
## McNair Succeeds Stanley at Texas Co.

John A. McNair has been appointed General Attorney in charge of the legal affairs of The Texas Company in its Pacific Coast Territory, it was announced on Dec. 5 by Torrey H. Webb, Vice President. Mr. McNair succeeds Charles C. Stanley, whose retirement became effective December 1 but who will remain with the company in a general advisory capacity.



Charles C. Stanley

Mr. Stanley joined the company in 1928, prior to which time he was a member of the law firm of Morgrage and Stanley, and attorney for the California Petroleum Corporation, which was taken over by The Texas Company in 1928. He is a veteran of the Spanish American War and World War I. After the latter war he maintained his interest in military affairs for many years, holding the rank of Lieutenant Colonel, Infantry. He is a member of the American Bar Association, also the Bar Associations of California, Nevada and Los Angeles.



John A. McNair

Mr. McNair, a native of Texas and graduate of the University of Texas, was first employed by Texaco in 1921 in the Legal Department at Houston. He also served some time as attorney in the New York office, and has been associated with Mr. Stanley in the legal affairs of the company on this coast since 1928. He is a member of the State Bar of California, and the Texas State Bar Association.

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## Rader Joins Dia-Loy Tubing Survey Company

C. M. Rader, widely known petroleum engineer, has become associated with the Dia-Loy Tubing Survey Company of Whittier, Calif., as general sales manager in charge of western territory.

C. M. Rader

Mr. Rader has been identified with the oil production and supply industries for the past 24 years, having served in various capacities in the Rocky Mountains, Mid-Continent and California fields. Most recently he was associated with Kobe, Incorporated, of Huntington Park, Calif., with which company he held an executive position for several years.

In his new connection Mr. Rader will supervise promotion and development of oil field service for the Dia-Loy company, which has specialized in making surveys of tubing and casing to determine the reduction of wall thickness from excessive wear, corrosion, electrolytic action, etc. The survey is made with a specially designed and patented instrument which, when run in the well, transmits its measurements through an electric conductor cable to a recording device on the surface.

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## Dean Swift Opens New York Offices

Dean Swift, formerly of Seattle, announces the opening of offices in New York City. He will represent the Western Gear Works' plants at Seattle, Washington, Lynwood and Vernon, California, and Western Gear's associate plant, the Pacific Gear & Tool Works of San Francisco.

The Western Gear plants are manufacturers of all types of gears and geared machinery. Their products include speed reducers, marine propulsion units, cranes and crane machinery, winches, hoists, deck machinery, capstan gearing, airplane gears and actuating units, ship lighting sets, various types of transmissions and oil field pumping equipment.

Dean Swift

## Signal Oil and Gas Company Announces Staff Changes

Signal Oil and Gas Company announces the appointment of Mr. Sherman N. Shumway as Vice-President and Director in charge of the Company's subsidiary interests.

Although a native of Los Angeles, Mr. Shumway comes to California from Bangor, Maine, where for the past 11 years he has been president of the Merrill Trust Company of that city, and past president of the Maine Bankers' Association.

**Sherman M. Shumway**

Serving as a Lieutenant-Colonel in World War I with the 103rd Infantry of the 26th Division, Mr. Shumway returned after the war to New England where, after graduating from the Harvard Law School, he practiced law for ten years throughout the State of Maine.

In addition to his recent appointment as Vice-President of Signal Oil and Gas Company, Mr. Shumway also serves as Chairman of the Board of System Freight Service, a Signal subsidiary.

Other recent staff changes announced by the Company are as follows:

G. L. Young, Chief Engineer, has been elected a Director of the Signal Oil and Gas Co. as well as Vice-President and Director of the Signal Oil Company. Mr. Young has been associated with the Company almost since its inception in 1922.

R. W. Heath, manager of the Gas Department, who has been with the Company since 1923, has been elected a Vice-President and Director of Signal Royalties Company.

In the Sales Department, C. H. Porch, formerly Division Manager at Portland, was recently transferred to become Manager of the Company's Divisional Headquarters at Alameda.

J. R. Staples, formerly Division Manager at Seattle, is now in charge of both the Portland and Seattle Divisions for Signal.

E. F. Steen, formerly Central Division Manager, has been elected President of the System Freight Service with headquarters in Los Angeles.

---

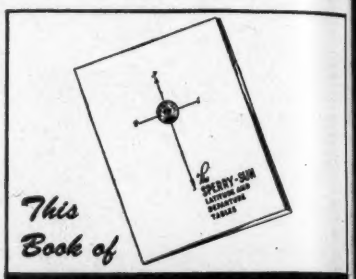
## Laird Advanced by Chiksan

Lee J. Laird, formerly assistant sales manager and recently in charge of Production Control, has been appointed Sales Manager of Chiksan Tool Company, Brea, California. In addition, Mr. Laird becomes Vice President of the company.

**Lee J. Laird**

Lee Laird's experience during 10 years as a member of the Chiksan organization fully qualifies him for his new responsibilities. He is widely known both in the Petroleum Industry and among manufacturers in many other lines of industry. Laird successfully introduced Chiksan Aero Hydraulic Swivels to the aircraft industry, resulting in the adoption of these units as standard equipment on a number of combat and transport planes.

Under Laird's direction, extensive plans are under way to develop many new applications for Chiksan Ball Bearing Swivels as well as new types of swing joints which will greatly enlarge Chiksan's market.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# THIS LAUGH

# OFF!!

A woman went to buy a drinking trough for her dog, and the shopkeeper asked her if she would like one with the inscription, "For the Dog."

"It doesn't really matter," she replied. "My husband never drinks water and the dog can't read."

---

An eastern pilgrim, motoring through a rural countryside, in the days when one could venture that far without rationing restrictions, paused at a particularly dilapidated farm to inquire directions.

"What are you raising?" he asked the farmer. "What's your main crop?"

"Hawgs," was the laconic response.

"Hogs?" repeated the pilgrim. "Do they pay better than corn or tobacco?"

"Wal, no," admitted the farmer. "No. I cain't say's they do. But," and he brightened perceptibly, "hawgs don't need no hoein'."

---

I'm feeling a little frail tonight.
Will you stop calling me that!

---

A story, which is probably not true, is told of a young Brooklyn soldier who was on maneuvers in Oregon. Having a few minutes to himself after evening chow, he strolled out into the woods and soon came back with a handful of rattlesnakes rattles. "Where in the world did you get them?" gasped his alarmed companion.

"Off'n a woim," replied the lad from Brooklyn.

---

My love has went
He did me dirt
Me did not know
Him were a flirt.
And now, my friend,
May Heaven forbid
That you be dood
Like I been did.

"You're an apt boy. Is your sister apt, too?"

"If she gets a chance, she's apt to."

---

"F-e-e-t," the teacher declaimed. "What does that spell, Johnny?"

"I dunno."

"What is it that a cow has four of and I have only two?"

So Johnny told her.

---

It was a race between the stork and the ambulance and the stork won on the hospital lawn.

Eventually, the husband received a bill including the item: "Delivery room, $25."

He wrote a hot letter, insisting his wife had never been in the delivery room.

Back came another bill carrying a correction: "Greens fees—$25."

---

He: "I'm going to take my girl down to Florida with me."

Him: "Going to Tampa with her?"

He: "Mi-am-i"

---

He: "Your husband looks like a brilliant man. I suppose he knows everything."

She: "Don't fool yourself; he doesn't even suspect a thing."

---

He: "I tried to see you yesterday, but without avail."

She: "O.K. Then I'll take it off."

---

"Why the black eye?"

"Well, it was the first time I was ever a judge at a beauty contest and I was forced to sort of feel my way around."

---

"I'd better warn you—my husband will be home in less than an hour."

"But I've done nothing I should not do."

"Well, I just wanted to warn you that if you're going to, you'd better hurry."

Sheriff: "Hey, there's no swimming allowed here."

She: "Why didn't you tell me before I got all undressed?"

Sheriff: "Well, there's no law against undressing."

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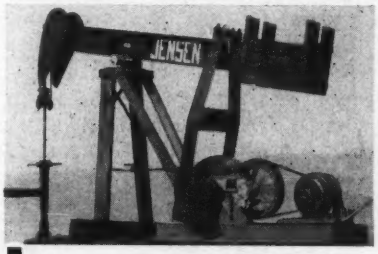


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# Field Development

## Los Angeles Basin

### Long Beach Work Continues

Shell Oil Co.'s projected deep test at the east end of the Long Beach field is drilling ahead below 5476 ft. Located near 20th and Obispo Aves., the company expects the well to carry to basement. The company's Stakemiller-Rose No. 1 is drilling ahead after cementing 13⅜ inch surface casing at 1356 ft. with 1000 sacks.

### Old Montebello Well Pumping

C. C. Killingsworth Barry No. 2, on sec. 6-2s-11w, deepened to 3592 ft. and completed on the pump from intervals open below 2994 ft. making 60 bbls. per day net. The company plans additional rework on other wells in this leasehold.

### Rosecrans Field Active

Development in the Rosecrans field of Los Angeles County is hitting a new level. Currently at work is Century Oil Co.'s Wright No. 16 which is drilling at 4000 ft., Shell Oil Co.'s Bank No. 4 and Union Oil Co.'s Howard Park No. 37. A scheduled redrill is Nevada Petroleum Co.'s Colby No. 2. Latest completed in the field was Union Oil Co.'s Rosecrans No. 49 which finished at plugged depth of 6851 ft. flowing a settled 167 B/D clean 34 gravity oil and 156 MCF gas through a 24/64 inch bean.

### Buena Park Well Working

General Pet. Corp.'s Heath No. 2, sec. 34-3s-11w, is redrilling to straighten hole at 8157 ft. The well seeks a better structural position than that which produced a small amount of oil in Heath No. 1 on the same section. To the south, on sec. 1-4s-11w, The Texas Co. Stern No. 1 is drilling ahead in hard shale at 7907 ft.

### Rosecrans Wildcat Again Fishing

Wilshire Oil Co.'s Central Heights No. 1, southwest of Olive and Central Aves., a mile east of the south tip of the Rosecrans field and due north of the Dominguez field, is yet finishing drill pipe after reaching a total of 5739 ft.

### Chatsworth Area Well Starting

Shell Oil Co. is rigging up on Schonfield No. 1 in the Chatsworth area of Los Angeles County. To be drilled on contract by the McFann Drilling Co., the well is located 330 ft. north and 330 ft. east from the west ¼ corner of sec. 30-2n-16w. On sec. 22-1n-17w, in the Calabasas area, A. B. Simons is rigging up to spud his well No. 1.

### Montebello Area Well Drilling

Hilo Oil Company Bishop-Hilo-Lapworth No. 1, sec. 4-2s-11w, east

**LOS ANGELES BASIN WILDCATS**

| Area | Well | No. | Section | Depth | Status |
|---|---|---|---|---|---|
| Aliso Canyon | Standard Oil Co., Del Aliso | 1 | 29, 3-16 | 9161 | Cleaning out |
| | Standard Oil Co., Frew | 1-3 | 29, 3-16 | 6310 | Drilling |
| | Standard Oil Co., Ward | 3-1 | 27, 3-16 | 6895 | Fishing D.P. |
| Calabasas | Simons, A. B., Well | 1 | 22, 1-17 | | Rigging up |
| Castaic | Charter Oil Co., Well | 1 | 18, 5-16 | | Graded roads |
| Chatsworth | Shell Oil Co., Schonfeld | 1 | 30, 2-16 | | Rigging up |
| Hasley Canyon | Shell Oil Co., Claiborne | 88-4 | 4, 4-17 | 4015 | Rig pump |
| Las Llajas | Standard Oil Co., Brady Est. | 2-1 | 13, 3-17 | 2569 | Abandoned |
| | Standard Oil Co., Brady Est. | 2-1A | | | Rigging up |
| Montebello | Hilo Oil Co., Lapworth | 1 | 4, 2-11 | 3971 | Drilling |
| | Hilo Oil Co., Bishop-Hilo-Lapworth | 2 | 4, 2-11 | | Rig |
| | Hilo Oil Co., Montebello-Pellissier | 1 | 4, 2-11 | | Foundation |
| Newhall | Anderson, J. I., Tomato Can | 1 | 11, 3-16 | 775 | Drilling |
| | British-Am. & The Texas Co., NLF | 1 | 21, 4-17 | 7699 | Testing |
| | British-Am. & The Texas Co., NLF | 2 | 21, 4-17 | | Foundation |
| | Standard Oil Co., N. L. & F. | 3-2 | 19, 4-17 | 4810 | Drilling |
| No. Covina | The Texas Co., Covina | 27-1 | 7, 1-9 | 3471 | Drilling |
| Pico Canyon | Standard Oil Co., Pico C. O. | 42 | 1, 3-17 | 5364 | Drilling |
| Pomona | Jones, Everett, Well | 1 | 17, 2-9 | 356 | Drilling |
| Puente | Alleghany Pet. Co., Rowland | 1 | 14, 2-10 | 1186 | Prep. to pump |
| | Hacienda Oil Co., Well | 1 | 27, 2-10 | | Location |
| | Hansen, Melvin, Corehole | 3 | 24, 2-10 | 1900 | Idle |
| San Jose Hills | Ohio Oil Co., Legrand | 1 | 30, 1-9 | 932 | Drilling |
| | The Texas Co., Garnier | 1 | 35, 1-10 | 3271 | Drilling |
| Turnbull Canyon | Copital Co., Capital | 3-2 | 12, 2-11 | 4038 | Drilling |
| Rosecrans | Wilshire Oil Co., Central Heights | 1 | 28, 3-13 | 5739 | Fishing D.P. |
| Whittier | Mayo Oil Co., Grey | 1 | 17, 2-11 | 4974 | Pumping |
| | **Imperial County** | | | | |
| Brawley | Amerada Pet. Corp., Veysey | 1 | 9, 13-13 | | Rig |
| Holtville | The Texas Co., Grupe-Engebretsen | 1 | 8, 16-16 | | Set. boilers |
| | **Orange County** | | | | |
| Brea Canyon | Selbar Oil Co., Wardman-Comm. | 1 | 3, 3-10 | | Rig |
| Buena Park | Gen. Pet. Corp., Heath | 2 | 34, 3-11 | 8935 | Redrilling |
| | The Texas Co., Stern | 1 | 1, 4-11 | 7907 | Drilling |
| Costa Mesa | Macoil Co., Townsend | 3 | 21, 6-10 | | Prep. to spud |
| Kraemer | Mid. Cal. Pet. Co., Mid. Pet. | K-1 | 24, 3-9 | 2260 | Drilling |
| | **San Bernardino County** | | | | |
| Chino Hills | Chino Hills Oil Co., Kraemer | 2 | 33, 3-28 | 1020 | Drilling |

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of the Montebello field, is drilling ahead in hard conglomerate at 3971 ft. The company is proceeding ahead without showings, since a trial in the interval 2830 to 2975 ft. blew gas and recovered some oil. The company is completing rig for the second well on the same lease and has poured foundation for Montebello-Pellissier No. 1 in the same section.

## Huntington Beach Deep Test Working

Frank Vessels, of Oil Field Construction Co., has assumed operations on the Treasure Hill Oil Co. Rex. No. 12 at Summit and Smeltzer Aves. in the Huntington Beach field. Scheduled as a 10,000 ft. test, the well had redrilled to 4794 ft. and temporarily suspended under prior management. The current operator is cleaning out to resume making hole and expects to maintain continuous operations.

In the Five Point Section of this field Nicolai and Becker Oil Co., Fee No. 1, was redrilled and deepened to 3825 ft. where it went on the pump making 40 bbls. per day net oil. At the southeast flank of the field Hampshire Oil Co. well No. 1 was last reported coring sand and shale at the 3100 ft. level. Signal Oil and Gas Co. has been granted a contract by the State Lands Commission to develop State owned tidelands northwest of the Southwest Exploration Co.'s holdings. Work is expected to start on this acreage in the immediate future. According to conditions of the lease, one of the first two wells drilled must prospect to basement unless it discovers new deep zone production above the rock.

In the westerly field section Standard Oil Co. Huntington No. A-72 is re-rigging new equipment after blowing out and burning while pulling drill pipe from bottom at 5034 ft.

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# San Joaquin Valley

## Tejon Wells Producing

Reserve Oil & Gas Co.'s well No. 33-7, sec. 33-11n-19w, was last reported pumping 110 B/D clean 18 gravity oil from effective depth of 2720 ft. The company is starting No. 33-8 on an adjacent location. Richfield Oil Corp.'s Tejon No. B-55-34, sec. 34-11n-19w, flowed 30 bbls. daily clean 19.6 gravity oil and 923 MCF gas through a 46/64 inch bean from plugged depth of 2725 ft. Killed and placed on the pump, the well was showing but little fluid at press time.

## San Luis Obispo Well Scheduled

Tutin, F. W. & Twisselmann, Herbert H., are preparing to drill White No. 1 in the Shandon area of San Luis Obispo county. The driller will be located near the center of the southwest quarter of sec. 5-26s-15e.

## Coffee Canyon Well Planned

Standard Oil Co. is preparing to drill Hayes No. 1-11-28 northeast of the Coffee Canyon field. The project has been staked 240 ft. N. and 240 ft. E. of the southwest corner of sec. 28-27s-29e.

## Kern Front Well Starts

Richfield Oil Corp. has begun work on Hood-Bloemer No. 1 as a test some 500 ft. south of the present producing limits of the Kern Front field. The location is 1070 ft. N. and 2390 ft. E. of the southwest corner of sec. 26-28s-27e.

## Jacalitos Area Well To Start

Jacalitos Oil Co., headed by Glenn A. Harris of Whittier, is preparing to drill on sec. 30-22s-16e in the Jacalitos area of Fresno county. T & T Drilling Co. has been awarded the contract.

## Greeley Outpost Well Starting

The Texas Co. is preparing to drill at the south flank of the Greeley field. The well, KCL-Pioneer No. 77-32, is located in sec. 32-29s-26e.

## Western Gulf Discovery

Western Gulf Oil Co. Cohn Estate No. 1, sec. 3-30s-28e, in the Magunden area of Kern county, was completed in the interval 5785-5805 ft. making 53 B/D 15.5 gravity oil cutting 7.0%. At last report the well was killed to rig pump. The

### SAN JOAQUIN VALLEY WILDCATS

| Area | Well | No. | Section | Depth | Status |
|---|---|---|---|---|---|
| **Fresno County** | | | | | |
| Cantua | Tide Water Assoc. Oil Co., S. P. | 82-15 | 15, 17-15 | 3498 | Drilling |
| Jacalitos | Standard Oil Co., Well | 52-17E | 17, 21-15 | 3395 | Testing |
| | Tide Water Assoc. Oil Co., Well | 6-16 | 16, 21-15 | 1034 | Drilling |
| | Tide Water Assoc. Oil Co., Well | 78-16 | 16, 21-15 | 4546 | Completed |
| Helm | British-Am. Oil Prod., Mahoney | 1 | 6, 17-17 | 8305 | Drilling |
| Tranquility | Standard Oil Co., Paterson | 74 | 3, 16-14 | 5353 | Drilling |
| | The Texas Co., Calif.-Cotton | 36-23 | 23, 16-15 | 7684 | Drilling |
| **Kern County** | | | | | |
| Ant Hill | Amerada Pet. Corp., S. P. | 7-15 | 15, 29-29 | 1600 | Drilling |
| | Amerada Pet. Corp., S. P. | 38-15 | 15, 29-29 | 2150 | Drilling |
| Beardsley | Shell Oil Co., KCL | 1 | 24, 29-27 | | Rigging up |
| Canfield Ranch | Shell Oil Co., Inc., KCL-B | 45-27 | 27, 30-26 | 8391 | Testing |
| | Tide Water Assoc. Oil Co., KCL | 68 | 15, 30-26 | 4767 | Drilling |
| Delano | O'Kane & Brain, Well | 84-20 | 20, 25-26 | | Rigging up |
| Devils Den | C.C.M.O. Co., Bates | 2 | 20, 25-19 | 5185 | Drilling |
| | Hillview Oil Co., Hillview | 2 | 11, 25-18 | 778 | Pumping |
| Edison | Gen. Pet. Corp., Tarabino | 2 | 5, 29-29 | | Grade |
| | Lumpkin-Taylor & Assoc., Well | 1 | 16, 30-29 | | Location |
| | Richfield Oil Corp., Cauley | 2 | 16, 30-29 | | Rig |
| | Richfield Oil Corp., Cottonwood-Olcese | 1 | 20, 29-30 | 2114 | Abandoned |
| Fruitvale | General Pet. Corp., Kernlandia | 84-16 | 16, 29-27 | 7461 | Drilling |
| Greeley | Western Gulf Oil Co., KCL-A | 44-22 | 22, 29-26 | 6585 | Drilling |
| | The Texas Co., KCL | 77-32 | 32, 29-25 | | Grade |
| Gould Hills | Hilo Oil Co., Atlas-Anderson | 1 | 8, 29-21 | | Rig |
| | Union Oil Co., Richardson | 34-18 | 18, 29-21 | 2086 | Abandoned |
| Jasmine | Rothschild Oil Co., McDevitt | 1 | 24, 25-27 | | Location |
| Kern River | Wilkern Oil Co., Well | 1 | 17, 28-29 | 1253 | Standing |
| McKittrick | Americal Pet. Corp., Americal | 1 | 2, 30-31 | 5450 | Redrilling |
| | Standard Oil Co., McPhee | 2-1 | 36, 29-21 | 7539 | Drilling |
| Lindsey Hills | Standard Oil Co., Notz | 1 | 18, 28-22 | 4247 | Drilling |
| Lost Hills | Standard Oil Co., Cahn | 58 | 4, 27-21 | 3514 | Drilling |
| Magunden | Western Gulf Oil Co., Cohn Est. | 1 | 3, 30-28 | 6278 | Rig Pump |
| | Gene Reid Drlg. Co., Scott | 1 | 34, 29-25 | 4296 | Drilling |
| McVan | Butler Bros., Well | 2 | 14 ,27-27 | 1396 | Idle |
| Mount Poso | J. J. Tavis & Assoc., Well | 2 | 8, 27-28 | 2010 | Drilling |
| N. Edison | Standard Oil Co., Well | 45-21 | 21, 29-29 | | Grade |
| Poso Creek | Tide Water Assoc. Oil Co., Well | 4A | 33, 27-27 | 2351 | Abandoned |
| | Independent Expl. Co., Conoco | 53 | 33, 27-27 | | Grade |
| Round Mt. | Bender Drilling Co., Vedder | 14-1 | 14, 28-28 | 2660 | Pumping |
| | Gen. Pet. Corp., Schaller | 1 | 10, 28-28 | 2250 | Drilling |
| Saco | Gen. Pet. Corp., Kernway | 1-44 | 1, 29-26 | | Foundation |
| Sheep Springs | Independent Expl. Co., Salt Creek | 66 | 17, 29-21 | 3501 | Completed |
| | Rothschild-Bender Oil Ops., Anderson | 1 | 20, 29-21 | 4020 | Drilling |
| | Rothschild Oil Co., Exco | 1 | 21, 29-21 | 3264 | Drilling |
| | Trico Oil & Gas Co., Woods | 1 | 16, 29-21 | | Rig |
| Semitropic | Standard Oil Co., Fullerton | 1 | 25, 27-23 | 14206 | Drilling |
| So. Belridge | Bandini Pet. Co., Bacon | 1 | 27, 28-20 | 10495 | Idle |
| | Superior Oil Co., Crocker | 1 | 13, 29-21 | 4468 | Idle |
| | Superior Oil Co., Moor | 2 | 16, 29-21 | 4582 | Rng. casing |
| Strand | Standard Oil Co., KCL | 23-41 | 6, 30-26 | 8140 | Drilling |
| | Standard Oil Co., Robbins | 25-35 | 35, 29-26 | | Rigging up |
| | Standard Oil Co., Brittain | 61-2 | 2, 30-26 | 11009 | Redrilling |
| Sunset | T. W. A. Co., McBean | 86-36 | 36, 12-23 | 10621 | Drilling |
| Tejon | Drilling & Prod. Co., O.M.B. | 37-33 | 33, 11-19 | 653 | Drilling |
| | M. Metzenbaum, Well | 34-4 | 34, 11-19 | | Location |
| | Richfield Oil Corp., Tejon | A-67-35 | 35, 11-19 | 1458 | Drilling |
| | Reserve Oil and Gas Co., Well | 33-8 | 33, 11-19 | | Rigging up |
| Ten Section | Richfield Oil Corp., Old River, KCL | 2 | 3, 31-26 | 1144 | Drilling |
| Trico | Magee, H. H., Opr., Amal-Happold | 2 | 15, 25-24 | 11900 | Drilling |
| W. Edison | Richfield Oil Corp., Smith | 1 | 1, 30-28 | 4994 | Testing |
| **Kings County** | | | | | |
| Pyramid Hills | Pyramid Prod. Co., Spreckles | 1 | 27, 24-18 | 3088 | Cleaning out |
| Reef Ridge | Shell Oil Co., Crow | 41-2 | 2, 23-16 | | Rigging up |
| Stratford | So. Calif. Pet. Corp., Socal-Bergman | 88-32 | 32, 19-20 | 10400 | Drilling |
| **San Luis Obispo County** | | | | | |
| Midway | Richfield Oil Corp., Temblor Hills | 1-1 | 36, 31-21 | 6478 | Idle |
| | Richfield Oil Corp., Temblor Hills | 2-1 | 27, 32-22 | 1568 | Drilling |
| | Richfield Oil Corp., Temblor Hills | 2-2 | 27, 32-22 | 3050 | Abandoning |

new production is located approximately 1½ miles north of the Mountain View field and some 3 miles east of the old Union Avenue producing area.

### Hollister Area Well To Drill

B. C. Morrison, Operator, has built rig for a wildcat on the Fries Regan farm some 4½ miles south of the town of Hollister in San Benito county. The property falls in Township 13 south Range 5 east.

### East Edison Well Quits

Richfield Oil Corp. abandoned its Cottonwood-Olcese No. 1 on sec. 20-29s-30e in the Edison area of Kern county. Bottomed at 2114 ft. in Schist, the well found no saturated sands present at this location.

### Jacalitos Well Good Producer

Tide Water Assoc. Oil Co. Jacalitos No. 78-16, sec. 16-21s-15e, completed at 4546 ft. flowing 602 B/D clean 32.7 gravity oil and 250 MCF gas through a 32/64 inch bean under pressures of 145/375 lbs.

### Sheep Springs Well Finished

Independent Exploration Co. finished another Sheep Springs producer. The latest completion in this new producing area is Salt Creek No. 66 on sec. 17-29s-21e. Bottomed at 3501 ft. the well finished in Carneros oil sand flowing a 300 B/D rate clean oil through a 12/64 inch bean before shutting in to build more storage. The company has additional drilling immediately projected for the area.

### Coalinga Eocene Well Drilling

The Pauley brothers, Edwin W. and Harold R., are under way with Crandall No. 42-18 on sec. 18-19s-16e in the Coalinga Eocene Pool field. Located in the northwest quarter of the section, the well was last reported drilling at 1500 ft.

### Buena Vista Wells Good

Completions in the Buena Vista Hills remain consistently good. Latest completed here is Tide Water Assoc. Oil Co.'s well No. 38K on sec. 26-31s-23e. Bottomed at 3670 ft. the well finished in the E-2 zone flowing 976 B/D clean 32.4 gravity oil and 312 MCF gas through a 25/64 inch bean. Latest completed for Standard Oil Co. was No. 345-35B on sec. 35-31s-23e. This well bottomed at 3982 ft. to finish flowing a settled 506 B/D clean 30 gravity oil and 130 MCF gas through a 13/64 inch bean.

### Jasmine Area Well Projected

Rothschild Oil Co. is preparing to drill McDevitt No. 1 in the Jasmine area of Kern county. The projected driller is 300 ft. N. and 330 ft. E. of the southwest corner of sec. 24-25s-27e.

### Mojave Area Well Planned

Thos. M. Blake is preparing to drill Cinco No. 1 on sec. 22-31s-37e in the Mojave area of Kern county. The well is located 1584 ft. N. and 483 ft. W. of the southeast section corner.


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## Edison Outpost Blows Gas

British American-Capital Co. Portals No. 43-3, sec. 3-30s-29e in the Edison field area, is completing. Last tested in the gun perforated intervals 4815-4750, 4750-36, 4710-4700, 4700-4660 ft. the well flowed an estimated 25 B/D rate 52 gravity condensate and 7000 MCF gas through a 32/64 inch bean under pressures of 850/900 lbs.

## Kettleman Hills Well Completed

Standard Oil Co. well No. V63-33J, sec. 33-21s-17e in the Kettleman North Dome field, finished at 8275 ft. flowing 1234 B/D clean oil and 1469 MCF gas through a 48/64 inch orifice. The company has six other projects under way in this field.

## Elk Hills Drilling Keeps Steady Rate

Drilling on the Naval Petroleum Reserves in the Elk Hills field continues at an even pace with an average 23 strings at work. Under the direction of Standard Oil Co., general contractor to the Navy, many drilling contractors rigs are employed to achieve the high drilling average. Finished near the 3000 ft. level, wells here are generally substantial with rates running as high as 900 bbls. daily.

## Reef Ridge Well Started

Shell Oil Co. is moving in equipment to start drilling Crow No. 41-2 in the Reef Ridge area of Kings county. The driller is located in the northeast corner of sec. 2-23s-16e.

## Imperial County Well Scheduled

The Texas Co. is setting boilers for an early start on Grupe-Englebretson No. 1 near the town of Holtville in Imperial County. The well is located 530 ft. N. and 530 ft. E. of the S¼ cor. of sec. 8-16s-16e. On sec. 9-13s-14e, near the town of Brawley, Amerada Pet. Corp. has rig up for Veysey No. 1 and will spud upon completion of its Tar Springs Ranch project at Huasna.

## Gould Hills Well Quits

Union Oil Co. abandoned its Richardson No. 34-18, sec. 18-29s-21e, in gray Carneros sand after reaching 2086 ft. On section 8 of the Township Hilo Oil Co. is preparing to drill Atlas-Anderson No. 1.

## Ant Hill Production Again Augmented

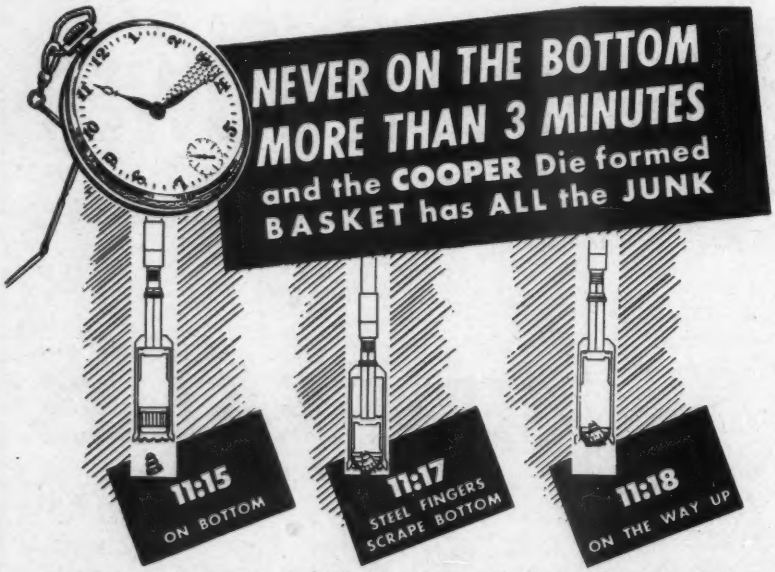
Amerada Pet. Corp. effected more production in the Ant Hill area of Kern County when its S. P. No. 8-15, sec. 15-29s-29e, bottomed at 4250 ft. in Schist and set 7 inch casing at 3724 ft. to complete in the gun perforated intervals 3691-3700 and 3670-80 ft. flowing 182 B/D clean 39.1 gravity oil through a 1 inch bean. The company is currently drilling Nos. 7-15 and 38-15 in the same section.

## Newport Beach Well Reworking

Macoil Co. redrilled old Banning-Townsend No. 2 on sec. 20-6s-10w in the Newport Beach field to a depth of 3500 ft. The operator will rerun liner and conventional gravel pack to reestablish production on the same solid basis which it achieved in well No. 1 on the lease. To the north, in the Costa Mesa area, the company is preparing to spud Townsend No. 3 as deep test near 17th and Whittier Sts. on sec. 21-6s-10w.

## Aliso Canyon Well Completed

Tide Water Assoc. Oil Co. completed its Standard-Sesnon No. 1-4 on sec. 28-3n-16w in the Aliso Canyon field. Bottomed at 9179 ft. and with 7-inch casing cemented at 9075 ft., the well finished flowing 330 bbls. daily, 19.3 gravity oil through a 64/64 inch bean. The well is producing from 124 ft. of Eocene Age sands. On an adjacent location the company is partially rigged to drill project No. 1-5.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# Coastal and Northern District

## Foxen Canyon Well Coring Showings

Four-Five-Six Oil Co., Wickenden No. 1 on sec. 34-9s-32w in the Foxen Canyon area of Santa Barbara County, is coring Chert showing oil at 3050 ft. Top of the Miocene was placed at 900 ft., and showed some saturation. Top of the good oily fractured brown shale was placed at the 1800 ft. level.

## Bel-Air Plans Cat Canyon Well

Bel-Air Oil Co. will soon start a wildcat to test for an extension of the West Cat Canyon field anticline. The company holds 3000 acres of the Raymond B. Price Ranch and has an immediate test scheduled.

## South Mountain "Cat" Coring

Los Nietos Co., L.B.H. No. 1, sec. 22-3n-21w near the South Mountain Field, is coring shale and oil sand at 4402 ft.

Within the field limits the British American Oil Prod. Co., Richardson Ranch No. 1 is drilling at the 1500 ft. level; F. E. Fairfield, S. M. No. 2 is making hole at 900 ft., and Pacific Western Oil Corp., Yale-Richardson No. 3 is testing shut-off on a 7 inch combination string landed on bottom at 4216 ft., and cemented through perforations at 2721 ft. This company has two additional projects scheduled for immediate work. Macoil Company is grading roads to its drilling site on sec. 19-3n-20w in this field.

## Ventura Avenue Well Completed

Shell Oil Co., Taylor No. 184 completed at 8734 ft. flowing a settled 446 B/D rate clean 32 gravity oil and 259 MCF gas through a 16/64 inch bean. Shell and Tide Water each have large drilling programs in this field. Also active here is British-American Oil Prod. Co. which is drilling Hartman No. 15 at 7600 ft.; Lloyd Corporation, Ltd., Well No. 15 which is yet drilling in the grass roots, and General Pet. Corp., which is drilling its Barnard No. 15-A.

## Santa Maria Valley Maintains Steady Pace

Work in the Santa Maria Valley field continues at its usual high average with Union Oil Co. leading in numbers of strings at work. Among the latest completions was Bel-Air Oil Co., Northman No. 1, sec. 35-10n-33w, which completed making 1200 B/D rate 14 gravity oil cutting 20%. Late starters in the field are Kern Drilling Co., O'Donnell No. 1 in sec. 28-10n-34w and Macoil Company, Lloyd No. 1 on sec. 29 of the township. On sec. 31-10n-33w Rothschild Oil Co. is preparing to redrill its Kemp No. 1 after finding little fluid in the original hole at 4961 ft.

## New Bardsdale Wells Scheduled

Two new wells are scheduled for the Bardsdale field. Next under way will be San Marino Oil Co.'s Capital Crude No. 3 which is rigging up on sec. 7-3n-19w. In the same section Wilshire Oil Co.'s C. E. Dryden No. 1 is drilling ahead at 6420 ft., while the company plans to drill Burson No. 1 on the adjacent sec. 6.

## Capitan Deep Test Started

Shell Oil Co. has completed rig and is laying lines to a site for Covarrubias No. 1-35 in the Capitan field of Santa Barbara County. Located in the field on sec. 32-5n-30w,

### COASTAL COUNTIES WILDCATS

| Area | Well | No. | Section | Depth | Status |
|---|---|---|---|---|---|
| | **Santa Barbara County** | | | | |
| Cat Canyon | Union Oil Co., Santa Maria Realty | 1 | 10, 9-33 | 5405 | Completing |
| Foxen Canyon | Four-Five-Six Oil Co., Wickenden | 1 | 34, 9-32 | 3920 | Drilling |
| Gato Ridge | Barnsdall Oil Co., Pezzoni | 2 | 15, 8-32 | 3877 | Drilling |
| Gaviota | Standard Oil Co., Hollister | 1 | 35, 5-33 | | Rig |
| Los Olivos | Hub Oil Co., La Laguna | 1 | 7, 7-30 | 4090 | Drilling |
| | **Ventura County** | | | | |
| Camarillo | Barth, D. A., Well | 1 | 32, 2-20 | 520 | Idle |
| Ex-Mission | Union Oil Co., Adams | 42 | 19, 4-21 | 3034 | Abandoned |
| Eureka Canyon | El Rika Oil Co., Well | 8 | 33, 4-18 | | Location |
| Happy Camp | Cal-Camp Oil Corp., Harrington | 1 | 21, 3-19 | | Grade roads |
| Hopper Canyon | Dodge, Inc., Signal | 7 | 13, 4-19 | 2673 | Redrilling |
| Ojai | Ellington, L. E., Well | 1 | 8, 4-21 | 1262 | Fishing D.P. |
| | Volunteer Pet. Corp., Hilltop | 2 | 7, 4-21 | | Rigging up |
| | Volunteer Pet. Corp., MacGregor | 1 | 7, 4-21 | | Grading |
| Oxnard | Lloyd Corp., Ltd., Todd | A-1 | 6, 1-22 | 4208 | Drilling |
| Santa Paula | Standard Oil Co., Santa Paula | 1 | 10, 4-20 | | Grading |
| Sespe | Assoc. Pip. & Eng. Co., A.P.&E. Co. | 1 | 5, 5-19 | 300 | Suspended |
| | Volunteer Pet. Co., Tar Creek | 3 | 28, 5-19 | 2373 | Rig pump |
| | Merchants Pet. Co., Well | 9 | 1, 4-20 | 480 | Drilling |
| South Mt. | Los Nietos Co., L.B.H. | 1 | 22, 3-21 | 4402 | Drilling |
| | Wilshire Oil Co., Petit | 2 | 16, 3-20 | 1589 | Drilling |
| Timber Canyon | Hickey Noble J., Temple | 1 | 22, 4-21 | 775 | Idle |
| | **San Luis Obispo County** | | | | |
| Arroyo Grande | McDuffie, Wm. C., Dollie | 3 | 6, 32-13 | 2288 | Idle |
| Tar Springs | Amerada Pet. Corp., Tar Springs | 1 | 25, 31-14 | 3192 | Drilling |
| Shandon | Tutin & Twisselmann, White | 1 | 5, 26-15 | | Location |

### NORTHERN COUNTIES WILDCATS

| County | Well | No. | Section | Depth | Status |
|---|---|---|---|---|---|
| Colusa | Standard Oil Co., Davis | 1 | 36, 18n-2w | | Location |
| Contra Costa | Shell Oil Co., East Bay | 1 | 13, 1n-3w | | Rigging up |
| | Shell Oil Co., Inc., Jacuzzi | 1 | 34, 2n-2e | | Location |
| Glenn | Standard Oil Co., Torres | 1 | 12, 18n-2w | 5180 | Drilling |
| Monterey | General Pet. Corp., Vierra | 1 | 7, 13s-2e | 1611 | Drilling |
| Sacramento | Shell Oil Co., Elk Grove | 9-1 | 17, 7n-6e | 2301 | Drilling |
| San Benito | Panoche Pet. Co., Panoche | 1 | 24, 16s-10e | 843 | Idle |
| Solano | Amerada Pet. Corp., Church | 1 | 35, 5n-2e | 3622 | Drilling |
| | Amerada Pet. Corp., Wineman | 1 | 26, 6n-2e | | Rigging up |
| | Oberholtz, A., Lambie | 1 | 22, 4n-1e | 5606 | Abandoned |
| | Shell Oil Co., Lambie | 1 | 25, 4n-1w | 2617 | Cleaning out |
| | Shell Oil Co., Lambie | 1A | 25, 4n-1w | | Cellar |
| | Standard Oil Co., Suisun | 4 | 5, 3n-1w | 4825 | Redrilling |
| | Standard Oil Co., Suisun | 5 | 31, 4n-1w | 4125 | Drilling |
| | Standard Oil Co., Fontana | 1 | 23, 3n-1w | 7944 | Fishing |
| | Standard Oil Co., Fontana | 2 | 32, 1n-1w | 4162 | Standing |
| | Standard Oil Co., Fontana | 3 | 9, 3n-1w | | Foundation |
| Stanislaus | Continental Oil Co., Azevedo | 1 | 27, 4s-7e | 3850 | Drilling |
| Sutter | Buttes Oilfields, Inc., Buttes-Ward | 1 | 2, 15n-1e | | Rigging up |
| Tehama | The Texas Co., Jelly-Bend | 18-8 | 8, 29n-2w | 7134 | Testing |
| Yolo | The Texas Co., Winchester | 8-1 | 4, 6n-4e | | Location |

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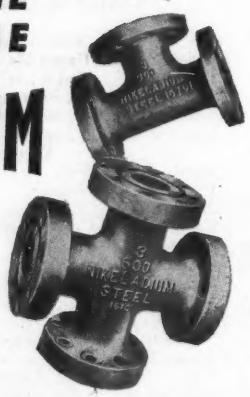

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the well will prospect below the present field producing horizons.

### Ojai Wells Now Started

Volunteer Petroleum Corp. is rigging up Hilltop No. 2 in sec. 7-4n-21w at Ojai. The company has also graded for MacGregor No. 1 on an adjacent location. The company's Tar Creek No. 3, sec. 28-5n-19w in the Sespe area, is rigging pump after bailing a small amount of oil from bottom at 2373 ft.

### Los Olivos Well Drilling

Hub Oil Company's La Laguna No. 1, on sec. 7-7n-30w, Santa Barbara county, is drilling in fractured shale at 4090 ft.

### Cat Canyon Well Completed

Union Oil Co.'s Palmer-Stendel B-1, in sec. 26-9n-33w, was completed at 5781 ft. pumping a settled 346 B/D 16.1 gravity clean oil. The well is open from the shoe of 8⅝ inch at 5068 to 5779 ft. where a 6⅝ inch perforated liner was landed.

### Two Scheduled At Gato Ridge

The Barnsdall Oil Co. is preparing to drill Magenheimer No. 2 on sec. 9-8n-32w at Gato Ridge, while The Petrol Corporation has poured foundation for Tognazzini No. 317-A on sec. 15-8n-32w. Each of the above producers is currently drilling in the field.

### Rincon Well Sidetracking

Beloil Corporation, Ltd., Hickey No. 1 on sec. 7-3n-24w in the Mussel Shoals area of the field, is plugged to set whipstock and sidetrack drill pipe which stuck at 3330 ft. where the angle of drift was measured at 63 degrees.


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## A.A.P.G. December Meeting

"The Argentine situation is a challenge to United States diplomacy. It can be solved, and the lack of a solution should not be charged against the people of Argentina," according to Edmund B. Besselievre, former resident of Argentina, who discussed "Argentina — the Problem of the Americas" at a meeting of the Pacific Section of the American Association of Petroleum Geologists at the University Club, Los Angeles, on the afternoon of December 15.

Friendly relations with Argentina can be achieved if the United States will recognize and appreciate the different cultural background of the Argentine people, Mr. Besselievre said. Argentina poses a peculiar challenge to U. S. diplomacy because, in contrast to the rest of the Western Hemisphere, Argentina is economically entirely independent of the United States. We do not buy enough of her products to create a trade balance favorable to her. Thus, with no economic leverage, the success of our relations depends more on diplomatic finesse in Argentina than in other Latin American countries where some of our mistakes are put up with for reasons of business.

Mr. Besselievre was definite in his opinion that the people of Argentina, although strongly pro-Argentine, are friendly to the United States. The present military government, he said, is not significant as being anything more than a routine military coup such as has been rather common in all the Latin American countries from time to time. He believes it has no connection with Nazism or Facism. There is an apparent strong German influence in the Army only because Argentina employed German military instructors for their competence and efficiency. The same influence is apparent in several other Latin American armies.

Mr. Besselievre, a civil engineer, spent seven years in Argentina just prior to the war in charge of Dorr Company interests. Most of the rest of his twenty-four years with that Company was spent in England, South Africa, and the other countries of Latin America. He is now in Southern California engaged with hygiene, sanitation, and water supply projects in Army and Navy camps. He was in the Construction Division of the U. S. Army in World War I.

The meeting completed the program for the twenty-first year of the Pacific Section which is the only sub-section of the largest geological society in the world.

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## A.A.P.G. Announces Committees

Glen Bowes, President of the Pacific Section, American Association of Petroleum Geologists has announced committees for 1945.

Elmo Adams, Honolulu Oil Corporation, and Frank A. Bell, Shell Oil Company, will represent the A.A.P.G. in advising with the Reconstruction and Re-employment Commission of the State of California with respect to its post war mapping program. These representatives will present the viewpoint of petroleum exploration and development to the Areal Mapping Project Committee of the Reconstruction and Re-employment Commission.

The Classification Committee, a new standing committee, is composed of Albert I. Gregersen of PAW, Chairman, Frank S. Parker of PAW, Alternate Chairman, James R. Dorrance of The Texas Company, Mason Hill of Richfield, and Harvey Lee of Union Oil Company.

This Committee will advise with the Division of Oil and Gas, the PAW, the Conservation Committee, and the operators on the naming of oil fields, pools, and zones, and it will handle statistics on exploration. An annual report will be made.

At the invitation of Richard Fenton, Chairman of the Stripper Well Industry Advisory Committee for California, the A.A.P.G. Pacific Section President nominated James R. Dorrance of The Texas Company, Harvey Lee of Union Oil, and Frank S. Parker of PAW. The nominees were then appointed by Mr. Fenton to serve on the Nomenclature and Engineering Subcommittee of the Stripper Well Industry Advisory Committee.

For the 1945 annual convention John Hazzard of Union Oil Company is chairman of the Program Committee and W. P. Wynham of Standard Oil is co-chairman. John McMillan of Fullerton Oil is chairman of the Arrangements Committee and Jerome O'Brien, Consultant, is co-chairman.

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## Del Valle Field Well Drilling

R. E. Havenstrite, Operator, Liebhart No. 2 on sec. 15-4n-17w is drilling ahead in oil stained sands at 8222 ft. The well flowed a 500 B/D rate gross oil and 15,000 MCF gas on test of the interval 7951 to 8017 ft. and blew gas and salt water on trial of the interval 8045 to 8140 ft. The company plans to start immediately on Liebhart No. 3 in the same section. The Operator's Barnes No. 5 in sec. 16 of the township is drilling ahead at 5650 ft.

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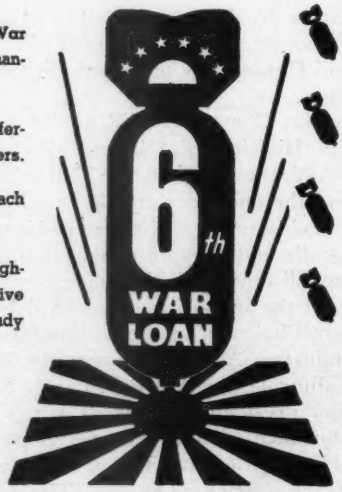


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